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AGRICULTURAL AND MECHANICAL COLLEGE OF TEXAS

W. B. BIZZELL, President

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DIVISION OF ENTOMOLOGY

THE SWEET POTATO WEEVIL

B. YOUNGBLOOD, DIRECTOR

COLLEGE STATION, BRAZOS COUNTY, TEXAS

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THE SWEET POTATO WEEVIL

H. J. REINHARD

INTRODUCTION

The sweet potato weevil, *Cylas formicarius* Fabr., is the most destructive insect attacking sweet potatoes in Texas. For a number of years the ravages of this insect have been very severe; in some sections to such an extent that the production of sweet potatoes on a commercial scale has been abandoned. The importance of this pest cannot be overestimated when it is realized that it is now permanently established in Texas, and threatens to impair seriously the sweet potato industry of the State. During the period 1916-19, inclusive, the sweet potato crop of Texas amounted to approximately 30,000,000 bushels, valued at more than $40,000,000. Any pronounced insect ravages incident to this large industry must necessarily result in a great loss each year to the producers. A conservative estimate of the average annual loss in this State is 1,500,000 bushels. If the average price for the period 1916-19 is taken to be $1.10 per bushel, then the total loss for the entire period was more than $6,000,000. In addition to this direct loss to the planters, there must be taken into consideration the indirect losses incurred by the failure of growers to plant a normal acreage because of the ravages caused by this weevil. There is no way of ascertaining this amount but it is doubtless a large item and must be given due consideration in estimating the extent of injury done to the sweet potato crop by this insect.

This pest has become of paramount importance to the sweet potato industry in the Southern States, and has been mentioned frequently in the economic literature. The studies recorded in this Bulletin were begun by the author in January, 1918, and continued until April, 1920.

HISTORY

According to the available references, the sweet potato weevil was first described by Fabricius (1) as *Brentus formicarius;* then under the designation of *Attelabus formicarius* (2); and finally, again under the first name, *Brentus formicarius* (3). In these descriptions the insect is referred to as occurring in Tranquebar, India. The original home of the sweet potato weevil is not definitely known. It is undoubtedly of tropical origin, however, since its spread has been confined largely to tropical and semitropical regions. For many years subsequent to the appearance of the original description, the insect apparently attracted no attention, and was not mentioned in scientific literature. The first authentic record of it as an important enemy of sweet potatoes was made by Nietner (4) in 1857. This author in describing the

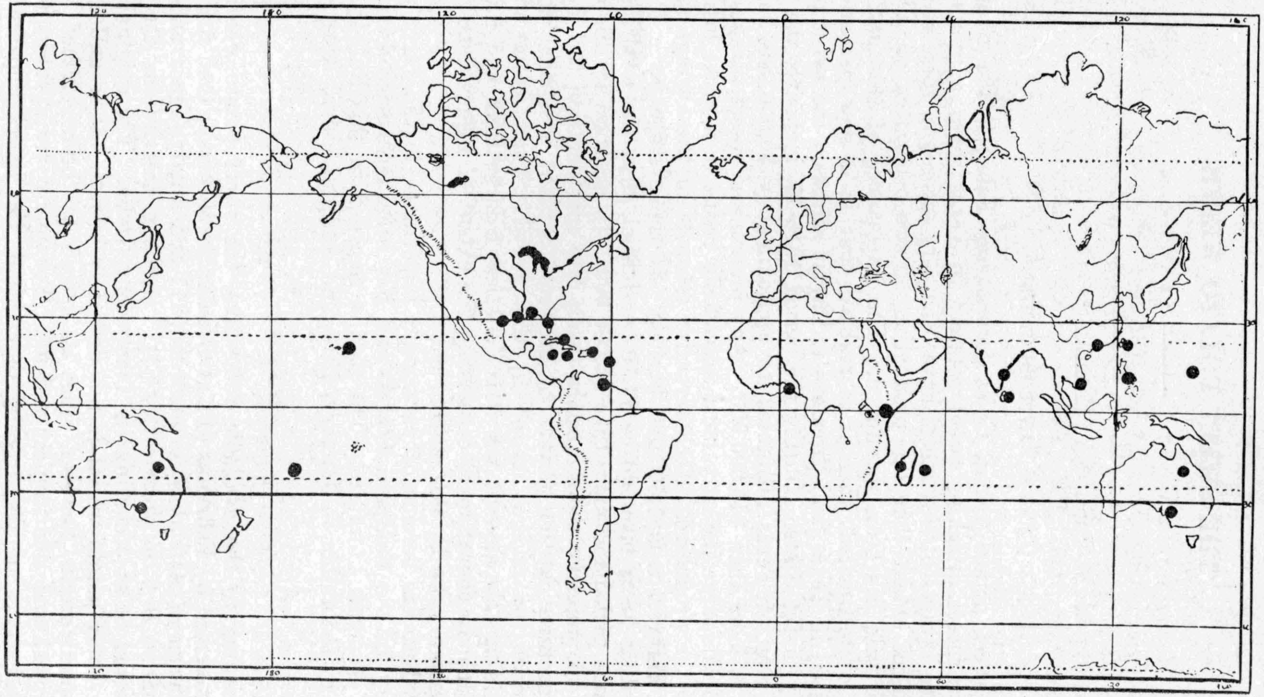

Figure 1. World distribution of the sweet potato weevil

ravages of the pest in northwestern Ceylon during the year 1856 states that in one instance practically the entire crop was destroyed. He also states that it occured throughout hundreds of acres at that time.

The species was present in the United States as early as 1875, according to Le Conte and Horn (6), who reported it from New Orleans, Louisiana. These authors also recorded it from Cochin-China, India, Madagascar, and Cuba. In 1879 Comstock (7) reported an infestation occurring the previous year near Manatee, Florida, with the statement that it "* * * seems to threaten the destruction of the sweet potato crop of this country". He also described the different stages of the insect at that time. Riley and Howard (8) record the occurrence of the weevil in Harris County, Texas, and Price (9) in 1895 noted the presence of the weevil at College Station, Texas. From this time to the present the insect has spread over Texas and now occurs in practically all the important sweet potato growing districts in the State.

There is no very definite knowledge concerning the introduction of this pest into the United States. It was noted in Louisiana and Florida at about the same time, and only a few years later in Texas. This seems to indicate that it was introduced at several points on the Gulf Coast, from which it spread inland. Since the initial points of infestation are ports of entry for the West Indies trade, it is generally concluded that the insect was imported from the West Indies.

DISTRIBUTION

In Figure 1 is given the world distribution of the sweet potato weevil, according to the available references on this species. It is interesting to note that its range of distribution is confined almost entirely to tropical and semitropical regions. However, the weevil is wide-spread within these latitudes, and is present on most continents and many islands.

In Texas the approximate distribution is shown by the shaded portion of the map shown in Figure 2. The dots show recorded distribution by counties, and the double shaded area the region of greatest destruction.

SYSTEMATIC POSITION

In his original description, Fabricius (1) placed this species in the genus *Brentus.* He defined the genus as follows: *Palpi inaequales, filiformes. Antennae moniliformes, infertae, rostro recto, porrecto, cylindrico.* In 1798 Fabricius (2) referred it to *Attelabus,* and later again placed it in the former genus *Brentus* (3). This arrangement remained undisturbed until after the erection of the genus *Cylas.* Olivier, according to Le Conte and Horn (6), placed the species in the latter genus. Summers (5) in 1875 described the sweet potato weevil as *Otidocephalus elegantulus,* which is quoted by Le Conte and Horn in synonomy with *Cylas formicarius.* Sanderson (11) refers it to the genus *Cylas* and family *Curculionidae.* Comstock (12), Blatchley and Leng (13), and Le Conte and Horn (6) all list the species in the genus *Cylas* of the family *Brenthidae.* Pierce (15) in the most recent account of the systematic status of the species places it in the family *Apionidae.*

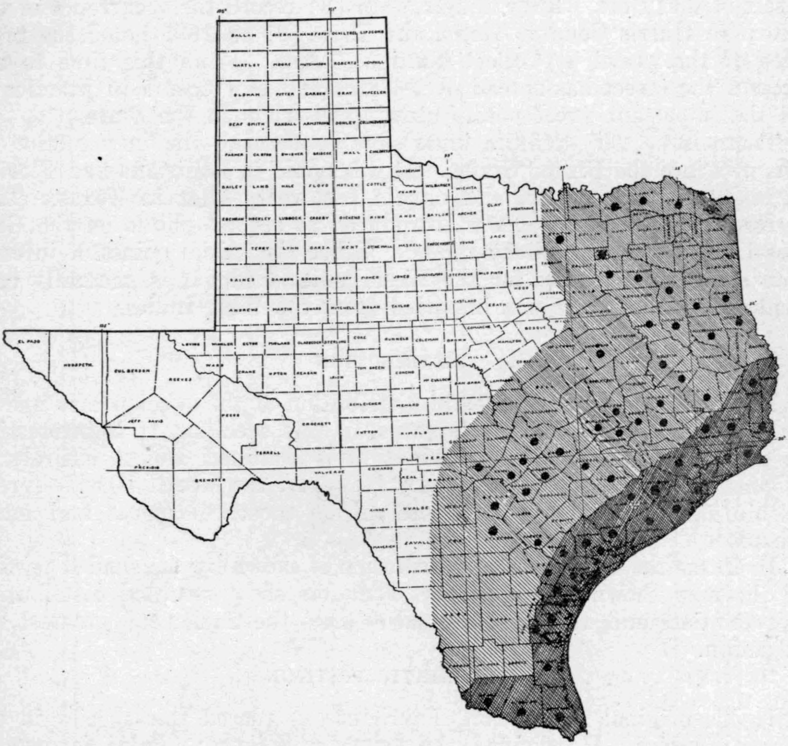

Figure 2. Map of Texas showing the distribution of the sweet potato weevil. Shaded area the approximate distribution. Heavily shaded portion the area of greatest destruction. Dots show actual records.

ALLIED SPECIES

According to Pierce (15) there are at least four species of weevils which attack sweet potato: *Euscepes batatae* Waterhouse; *Cylas formicarius* Fabricius; *Cylas turcipennis* Bohemann; and *Cylas femoralis* Faust. Summers (5) described a sweet potato weevil as *Otidocephalus elegantulus,* which Pierce considers to be a varietal form of *C. formicarius.* The species of the genus *Cylas* are closely related, and the following table as given by Pierce will serve to separate the species:

Table of Sweet Potato Weevils of the Genus *Cylas*

1. Male club twice as long as funicle or longer; antennae as long as head and thorax; head not more than one-fifth shorter than beak; elytra greenish, thorax red, head black, legs red with dark band . . . . *turcipennis* Boh.
Male club not twice as long as funicle . . . . 2.
2. Male club half to three-fourths longer than funicle, female club almost as long as head and thorax; head one-fourth to one-third shorter than beak; elytra bluish, thorax red, head black, legs red . . . . *formicarius* Fabr., var. *elegantulus* Summers.
Male club half longer than funicle; head as long as beak; antennae as long as thorax plus head behind eye; elytra black, with blue or green luster, suture piceous; thorax black, margins piceous; head black; legs dark red with black ring on femora . . . . *femoralis* Faust.

The three species mentioned above have similar habits and presumably all attack sweet potatoes, although fortunately there are no records of the occurrence of *turcipennis* and *femoralis* in this country.

COMMON NAMES

Since the insect has been recognized as an important enemy of sweet potatoes, it has been referred to in literature by several common names. Comstock (7) states that the larva is known as the "sweet potato root borer". Conradi (10) refers to the insect by the same name. Newell (14) calls it the "sweet potato root weevil", while Chittenden (16) in the most recent important account of the insect gives it the more appropriate name of "sweet potato weevil". The insect prefers feeding on the root or tuber*, but does not confine its attack to that portion of the plant. In fact, it can pass successfully a complete life cycle in the portion of the plant above ground. Since all parts of the plant are attacked, any term which specifies a particular portion subject to attack is, strictly speaking, a misnomer; therefore, the common name "sweet potato weevil" has been adopted for this insect in the present work.

ECONOMIC IMPORTANCE

From the time this insect was first reported an enemy of the sweet potato, its ravages have become correspondingly greater with the growth of the sweet potato industry. Growers frequently experience losses ranging from 20 per cent. to 50 per cent. of the entire crop in the field.

*The sweet potato is a subterranean tuberous root, but owing to the common usage of the term "tuber" it is referred to as such in the succeeding pages.

In some sections the weevil has been reported so abundant and destructive in consecutive years that sweet potatoes can no longer be grown profitably as a commercial crop.

The mild winter temperatures in Texas are not an effective natural check for the over-wintering weevils, and since the pest is distributed quite generally in Texas, there is hardly any one interested in the production of this crop who does not have to reckon with its ravages.

Newell estimates the annual loss at $3,500,000 for the Gulf country, which estimate other authorities consider to be conservative. About one-third of this amount is the approximate loss sustained by the Texas growers.

In 1920 the sweet potato crop ranked seventh in value among the most important crops in Texas, and its future value is limited by the work of this weevil.

FOOD PLANTS

From the name commonly applied to this insect it might be inferred that the sweet potato is its only food plant. While it is by far its most important food plant, the weevil feeds upon several other species of plants of the *Convolvulus* family, of which the morning-glory is a common example. The insect has been observed feeding on the roots of morning-glory plants collected in Brazoria County. There are about ten distinct species of *Ipomoea* or morning-glory which grow in the sweet potato producing sections of this State. Unfortunately, it has not been possible to make an accurate survey to determine the extent to which they exist, and afford a natural food plant for the weevil. Observations show that all varieties of sweet potatoes are subject to attack. Conradi described the insect as a "general feeder" and stated that any green succulent plant will be accepted as food for the adults. However, the insect has not been observed to propagate on any plant other than sweet potato and *Ipomoea,* and these undoubtedly constitute the natural food plants.

METHODS OF STUDY

Four-ounce tin salve boxes were used for making detailed observations on the life history of the sweet potato weevil in the laboratory. A pair of weevils was placed in a sterilized box with a section of sweet potato tuber for oviposition, during a 24-hour period. These tubers were removed each day and a fresh supply placed with the weevils. Notations were made on the hatching of the daily egg quota of each female, the pupation of the larvae, and emergence of the adults.

All life history observations were made in the laboratory, which was kept at ordinary room temperature. The existing temperatures were obtained by a recording thermograph, placed near the boxes containing the insect in all stages of development. Field notes were made in Brazoria and Matagorda Counties, and in the experimental plats of the Division of Entomology at College Station.

LIFE HISTORY

Former writers have mentioned the life history of this insect in a general way. Conradi (10) gives briefly his observations on the life history, which are quoted by other writers in discussing the insect. Chittenden (16) gives additional interesting notes on the life history obtained by High in southern Texas. Our detailed observations on the life history of the insect at College Station are given in the following pages. It will be noted that the life cycle of the sweet potato weevil is not divided into definite seasonal broods. The records show that under favorable conditions the weevils remain active and continue to breed throughout the year. Climatic conditions, however, have a positive effect on the life economy and undoubtedly restrict the abundance of the weevils at certain seasons of the year.

Egg

The egg is yellowish-white, minute, broadly oval in shape, and frequently constricted or narrowed at the attached end. Viewed laterally it is almost uniformly convex in outline. To the unaided eye the surface appears smooth and unpolished; under the microscope it has a slightly granular appearance, but with no distinctive sculpturings. The shell is very thin, soft and fragile, and eggs exposed to light and air shrivel and dry in a short time. The size of the egg is slightly variable, which may be noted in Table 1, giving the measurement of the greatest length and width.

Table 1 Egg Measurements

	Length, mm.	Width, mm.
Average	0.65	0.41
1	0.65	0.45
2	0.63	0.41
3	0.65	0.44
4	0.66	0.42
5	0.63	0.38
6	0.65	0.42
7	0.60	0.42
8	0.68	0.40
9	0.63	0.42
10	0.67	0.47
11	0.67	0.37
12	0.65	0.40
13	0.65	0.40
14	0.69	0.39
15	0.65	0.42
16	0.64	0.40
17	0.63	0.41
18	0.65	0.45
19	0.70	0.38
20	0.64	0.40

Embryology.—The color of the egg remains unchanged as the embryonic larva increases in size. When it is nearly developed it can be detected readily through the thin egg shell. The head of the larva is directed towards the unattached end of the egg. When matured the larva begins to eat its way through the shell.

Hatching.—Observations in most cases show that the larva emerges from the egg through the lower end, which leaves it at the beginning of feeding directed towards the interior of the tuber. However, in several instances the larva emerged through the upper end of the egg shell. The exit hole in the egg shell is always irregular and varies in size.

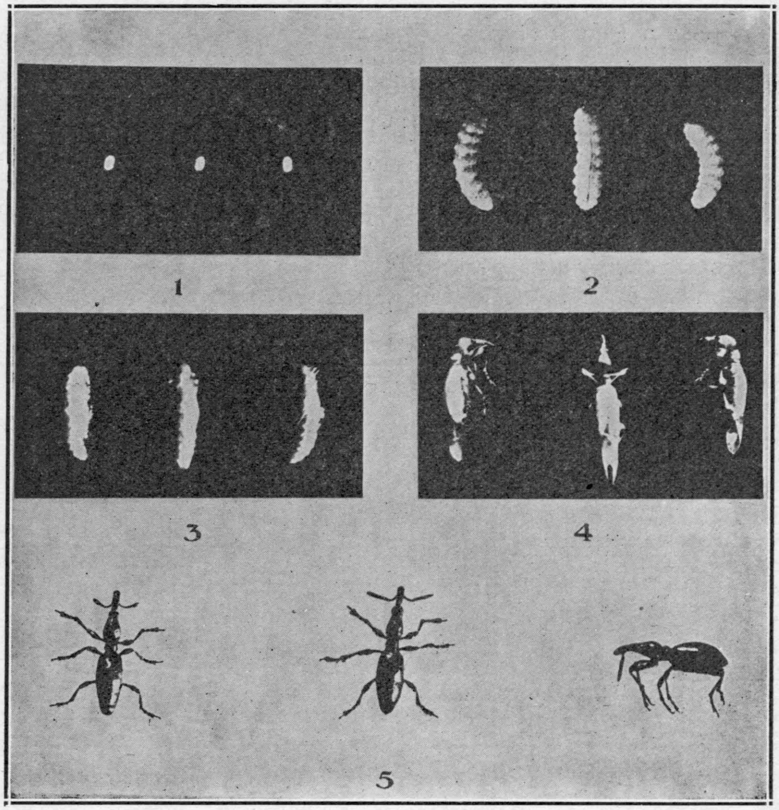

Figure 3. The sweet potato weevil: 1, eggs; 2, larvae; 3, pupae; 4, newly transformed adults snowing wings exposed; 5, adults, female on left males on right.

The larva may begin feeding before it has entirely emerged from the egg and leave it gradually as it tunnels into the tuber, but frequently it emerges completely from the egg shell and begins feeding in the egg cavity. As soon as hatching begins the color of the egg turns yellowish, and when hatching is completed the egg is transparent and the shell very brittle.

The length of the hatching period varies, and depends to a large extent upon existing temperatures. Under optimum conditions eggs have been observed to hatch in several hours, while in lower temperatures the period of hatching may extend over several days.

Duration of Egg Stage

The eggs are usually deposited in especially prepared cavities in the tubers or vines. The latter are sealed and it is impossible to make observations determining the exact length of the egg stage, without interfering to some extent with the natural conditions. The beginning of the stage was determined definitely by confining female weevils with uninfested tubers and noting the daily oviposition of each pair.

Table 2 Duration of Egg Stage

Lot No.	Laid	Hatched	Average period, days	Temperature		
				Max.	Min.	Mean
	1918	1918				
1	April 23	May 5-6	12.4	81	62	69.8
2	April 24	May 6	12	81	62	69.8
3	April 25	May 6-7	11.2	81	62	70.0
4	April 26	May 7	11	81	62	69.6
5	April 27	May 8	11	86	62	70.6
6	April 28	May 9	11	86	62	71.3
7	April 29	May 8-9	9.8	86	62	71.6
8	April 30	May 9	10	86	62	71.7
9	May 1	May 9	8	86	62	72.5
10	May 2	May 9-11	7.8	92	63	75.4
11	May 3	May 10	7	86	63	75.4
12	May 4	May 11	7	92	63	77.3
13	May 5	May 11	6	92	75	79.1
14	May 6	May 12	6	92	75	81.0
15	May 7	May 13	6	92	73	80.9
16	May 8	May 15	7	92	73	79.8
17	May 9	May 16	7	92	69	79.2
18	May 10	May 17	7	92	69	78.5
19	May 11	May 17-18	7.1	89	69	78.7
20	May 12	May 18-19	6.1	86	69	78.3
21	May 13	May 18-20	6.2	86	69	79.0
22	May 14	May 20	6	86	69	79.2
23	May 15	May 21	6	86	68	80.0
24	May 16	May 22	6	86	74	81.0
25	May 17	May 23	6	86	76	81.4
26	May 18	May 24	6	87	74	81.4
27	May 19	May 25	6	87	74	82.0
28	May 20	May 26	6	87	74	82.1
29	May 21	May 26-27	5.7	87	74	82.6
30	May 22	May 27-28	5.1	87	74	82.5
31	May 23	May 27-28	4.9	87	74	82.7
32	May 24	May 29	5	87	75	83.0
33	May 25	May 30	5	89	75	83.1
34	May 26	May 31	5	89	75	83.3
35	May 27	June 1	5	89	75	83.4
36	May 28	June 3	6	89	77	83.9
37	May 29	June 4	6	89	77	83.7
38	May 30	June 5	6	89	77	83.6
39	May 31	June 6	6	96	77	84.3
40	June 1	June 6	5	96	77	84.3
41	June 2	June 7	5	97	77	86.1
42	June 3	June 8	5	97	79	88.4
43	June 4	June 9	5	97	81	90.6
44	June 5	June 10	5	97	81	92.7
45	June 6	June 12	6	100	87	93.5
46	June 7	June 12	5	100	87	93.5
47	June 8	June 13	5	102	87	94.2
48	June 9	June 14	5	102	87	94.5

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature Max.	Min.	Mean
	1918					
49	June 10	June 15	5	102	87	94.7
50	June 11	June 16	5	102	88	94.9
51	June 12	June 17	5	102	90	94.9
52	June 13	June 18	5	103	89	94.6
53	June 14	June 19	5	107	89	96.1
54	June 15	June 20	5	107	89	96.8
55	June 16	June 21	5	107	89	97.7
56	June 17	June 22	5	107	89	98.4
57	June 18	June 23	5	107	93	99.0
58	June 19	June 24	5	105	93	98.8
59	June 20	June 26	6	102	93	96.6
60	June 21	June 26	5	102	93	98.4
61	June 22	June 27	5	103	94	98.7
62	June 23	June 28	5	103	94	98.6
63	June 24	June 29	5	103	94	98.3
64	June 25	June 30	5	103	94	98.4
65	June 26	July 1	5	103	94	98.7
66	June 27	July 1-2	4.8	103	94	98.6
67	June 28	July 3-4	5.2	103	94	96.7
68	June 29	July 4	5	102	85	96.4
69	June 30	July 5	5	102	85	95.8
70	Dec. 17	Dec. 26-28	10	94	73	82.2
71	Dec. 18	Dec. 28	10	94	73	81.8
72	Dec. 19	Dec. 29-30	10.8	94	73	82.1
73	Dec. 20	Dec. 30-Jan. 1, 1919	11.2	95	73	82.1
74	Dec. 21	Dec. 30-Jan. 2, 1919	11.6	95	65	81.0
		1919				
75	Dec. 22	Jan. 2-3	11	95	65	80.3
76	Dec. 23	Jan. 3	11	95	65	80.6
77	Dec. 24	Jan. 6-7	13.1	95	65	79.9
78	Dec. 25	Jan. 7	13	95	65	79.7
79	Dec. 26	Jan. 7-10	13.5	95	65	78.7
80	Dec. 27	Jan. 9-11	14.1	95	65	79.0
81	Dec. 28	Jan. 10-11	14	95	65	78.9
82	Dec. 29	Jan. 11-12	14.1	95	65	79.0
83	Dec. 30	Jan. 12-15	13.9	95	65	78.9
84	Dec. 31	Jan. 14-16	14	92	65	78.2
	1919					
85	Jan. 1	Jan. 14-16	14.3	92	65	77.9
86	Jan. 2	Jan. 15-17	13.6	92	67	78.4
87	Jan. 3	Jan. 16-18	14.2	92	67	78.6
88	Jan. 4	Jan. 17-18	13.8	92	67	78.9
89	Jan. 5	Jan. 18-19	13.3	92	67	79.1
90	Jan. 6	Jan. 19-20	12.9	92	67	79.3
91	Jan. 7	Jan. 19-20	12.2	92	67	79.1
92	Jan. 8	Jan. 19-22	11.7	92	68	79.7
93	Jan. 9	Jan. 20-21	11.1	92	72	80.0
94	Jan. 10	Jan. 20	10	92	72	80.1
95	Jan. 11	Jan. 21-22	10.1	92	72	80.1
96	Jan. 12	Jan. 22	10	92	72	79.8
97	Jan. 13	Jan. 23-24	10.3	93	72	80.0
98	Jan. 14	Jan. 24-25	10.3	93	63	79.4
99	Jan. 15	Jan. 25-28	10.8	93	63	79.0
100	Jan. 16	Jan. 26-28	10.8	93	63	79.3
101	Jan. 17	Jan. 27-29	10.2	93	63	79.4
102	Jan. 18	Jan. 28	10	93	63	79.6
103	Jan 19	Jan. 28-29	9.6	93	63	79.7
104	Jan. 20	Jan. 29-30	9.8	93	63	79.7
105	Jan. 21	Jan. 30-Feb. 1	9.7	93	63	80.3
106	Jan. 22	Jan. 31-Feb. 1	9.2	93	63	80.2
107	Jan. 23	Jan. 31-Feb. 6	9.4	93	63	78.9
108	Jan. 24	Feb. 2-5	9.8	93	63	78.8
109	Jan. 25	Feb. 5-6	11.1	93	63	78.8
110	Jan. 26	Feb. 7	12	93	65	79.2
111	Jan. 27	Feb. 7-8	11.1	93	65	79.6
112	Jan. 28	Feb. 8-9	11.7	93	65	79.7
113	Jan. 29	Feb. 9-13	12.1	93	65	79.4
114	Jan. 30	Feb. 11-12	12.1	93	65	78.9
115	Jan. 31	Feb. 12-13	12.2	89	65	78.7
116	Feb. 1	Feb. 13	12	89	65	78.5
117	Feb. 2	Feb. 13-14	11	93	65	78.9
118	Feb. 3	Feb. 13-14	10.1	93	65	79.3
119	Feb. 4	Feb. 14-15	10.2	93	65	80.1
120	Feb. 5	Feb. 14-16	9.8	93	65	80.3
121	Feb. 6	Feb. 16	10	93	65	80.5
122	Feb. 7	Feb. 17	10	93	65	80.9
123	Feb. 8	Feb. 17-18	9	93	65	80.6
124	Feb. 9	Feb. 18-19	8.9	93	65	80.4
125	Feb. 10	Feb. 19-20	8.7	93	65	80.7
126	Feb. 11	Feb. 19-20	8.1	93	70	81.3

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature Max.	Min.	Mean
	1919					
127	Feb. 12	Feb. 20-21	8.2	93	70	81.3
128	Feb. 13	Feb. 22	9	93	63	80.3
129	Feb. 14	Feb. 23-24	8.9	93	63	78.6
130	Feb. 15	Feb. 24-25	9.3	93	63	78.9
131	Feb. 16	Feb. 25-26	9.2	93	63	79.0
132	Feb. 17	Feb. 26-27	9.2	90	63	78.8
133	Feb. 18	Feb. 27-March 1	10.5	90	63	79.0
134	Feb. 19	March 1-2	10.4	90	63	80.4
135	Feb. 20	March 4-8	12	95	63	80.3
136	Feb. 21	March 4	11	101	63	81.6
137	Feb. 22	March 4-6	11.2	101	71	83.1
138	Feb. 23	March 6-7	11.6	101	71	83.5
139	Feb. 24	March 7-8	11.3	101	74	84.3
140	Feb. 25	March 7-8	11.4	101	74	84.5
141	Feb. 26	March 8-9	11.2	101	73	83.9
142	Feb. 27	March 9	10	101	73	84.1
143	Feb. 28	March 10	10	101	72	83.4
144	March 1	March 11-14	10.3	101	72	82.6
145	March 2	March 12	9.6	101	72	83.3
146	March 3	March 12-13	9	101	72	82.0
147	March 4	March 14-16	10.5	98	72	81.0
148	March 5	March 15-16	10.1	90	72	80.2
149	March 6	March 16-17	10.2	90	72	80.1
150	March 7	March 17-19	10.8	86	72	79.1
151	March 8	March 18-19	11.2	86	72	78.7
152	March 9	March 19-20	11.6	86	72	78.7
153	March 10	March 20-22	11	86	71	79.2
154	March 11	March 22-23	11.5	86	71	79.2
155	March 12	March 22-24	11.1	86	71	79.0
156	March 13	March 24-25	11	86	71	79.2
157	March 14	March 25	11	86	71	79.0
158	March 15	March 25-26	11.3	86	71	78.6
159	March 16	March 26-27	11.5	86	71	77.9
160	March 17	March 28	11	86	71	77.9
161	March 18	March 29-30	11.8	88	71	78.3
162	March 19	March 31-April 1	12.5	88	71	78.8
163	March 20	March 30-April 1	11.8	88	71	78.9
164	March 21	April 2	12	88	71	79.0
165	March 22	April 3	12	88	71	78.5
166	March 23	April 3-4	11.5	88	71	78.5
167	March 24	April 4-5	11	88	71	78.6
168	March 25	April 5-6	11.5	88	71	78.7
169	March 26	April 6	11	88	71	78.8
170	March 27	April 7	11	88	72	79.6
171	March 28	April 8	11	88	73	80.2
172	March 29	April 9	11	88	73	79.9
173	March 30	April 10	11	88	71	80.3
174	March 31	April 10-11	10.2	88	70	80.2
175	April 1	April 11-12	10.4	90	70	80.3
176	April 2	April 12-13	10.6	93	70	80.0
177	April 3	April 13	10	93	70	81.4
178	April 4	April 14	10	95	70	82.2
179	April 5	April 15	10	95	70	82.7
180	April 6	April 16	10	95	70	83.3
181	April 7	April 17	10	95	70	83.0
182	April 8	April 18	10	95	70	82.5
183	April 9	April 19-20	10.2	95	70	82.7
184	April 10	April 20-21	10.6	95	70	83.2
185	April 11	April 22	11	95	72	83.7
186	April 12	April 23	11	95	72	83.9
187	April 13	April 23-24	11.2	95	72	83.9
188	April 14	April 24-25	10.3	92	72	83.5
189	April 15	April 25-26	10.6	92	72	83.6
190	April 16	April 25-26	9.7	90	72	83.4
191	April 17	April 26-27	9.5	90	75	83.7
192	April 18	April 27-28	9.1	93	77	84.5
193	April 19	April 28	9	93	77	84.6
194	April 20	April 28-29	8.5	93	77	84.8
195	April 21	April 29	8	93	77	84.9
196	April 22	April 30-May 1	8.2	93	76	84.6
197	April 23	May 1	8	93	76	84.7
198	April 24	May 2	8	93	76	84.8
199	April 25	May 3-4	8.1	93	76	85.5
200	April 26	May 4	8	93	76	85.5
201	April 27	May 5	8	93	76	86.2
202	April 28	May 6	8	93	76	85.9
203	April 29	May 7	8	93	75	85.0
204	April 30	May 8	8	93	75	84.6
205	May 1	May 9	8	93	75	84.0

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature		
				Max.	Min.	Mean
	1919					
206	May 2	May 10	8	92	75	82.6
207	May 3	May 11-12	8.4	90	71	80.6
208	May 4	May 12-13	8.7	90	71	80.3
209	May 5	May 14	9	94	71	80.5
210	May 6	May 15-16	9.8	94	71	80.7
211	May 7	May 18	11	100	71	82.8
212	May 8	May 18	10	100	71	83.2
213	May 9	May 18	9	100	71	85.0
214	May 10	May 19	9	100	71	86.3
215	May 11	May 19-20	8.7	100	75	87.4
216	May 12	May 20-21	8.4	100	75	88.0
217	May 13	May 21	8	100	76	88.7
218	May 14	May 22	8	100	76	88.0
219	May 15	May 23	8	100	76	88.0
220	May 16	May 24	8	100	76	87.0
221	May 17	May 25	8	98	76	86.0
222	May 18	May 26	8	93	76	85.4
223	May 19	May 26-27	7.3	93	76	84.8
224	May 20	May 28	8	93	76	85.2
225	May 21	May 29	8	94	77	85.3
226	May 22	May 30-31	8.8	94	76	85.1
227	May 23	May 31	8	94	76	85.0
228	May 24	June 1	8	94	76	84.9
229	May 25	June 1-2	7.8	94	76	85.3
230	May 26	June 2	7	94	76	85.5
231	May 27	June 3	7	94	76	85.5
232	May 28	June 4	7	93	76	84.3
233	May 29	June 5	7	93	76	83.7
234	May 30	June 7	8	93	76	83.6
235	May 31	June 8	8	100	77	84.8
236	June 1	June 9	8	101	77	86.2
237	June 2	June 10	8	101	77	85.8
238	June 3	June 10	7	101	80	86.2
239	June 4	June 11	7	101	76	86.6
240	June 5	June 11	6	101	76	87.7
241	June 6	June 12	6	101	76	88.9
242	June 7	June 13-14	6.3	101	76	89.7
243	June 8	June 14	6	101	76	89.2
244	June 9	June 15	6	96	76	88.0
245	June 10	June 15-17	6.7	96	76	87.2
246	June 11	June 17-18	6.2	96	80	88.1
247	June 12	June 19	7	95	80	88.0
248	June 13	June 20	7	95	80	88.0
249	June 14	June 21	7	94	80	88.0
250	June 15	June 22-23	7.1	94	80	87.7
251	June 16	June 22	6	94	81	88.7
252	June 17	June 23-24	6.3	94	81	88.7
253	June 18	June 25	7	94	81	88.6
254	June 19	June 26	7	94	81	88.4
255	June 20	June 27-28	7.3	94	81	88.2
256	June 21	June 28-29	7.6	93	81	88.2
257	June 22	June 28-29	6.2	93	83	88.5
258	June 23	June 29-30	6.4	95	84	89.1
259	June 24	June 30	6	95	84	89.1
260	June 25	July 1	6	96	84	89.7
261	June 26	July 2	6	96	84	90.7
262	June 27	July 3	6	96	84	90.1
263	June 28	July 4	6	96	87	91.0
264	June 29	July 5	6	96	88	90.2
265	June 30	July 6-7	6.7	97	89	90.8
266	July 1	July 7-8	6.8	97	85	89.9
267	July 2	July 8-10	7	98	85	90.9
268	July 3	July 8-11	5.7	100	85	92.2
269	July 4	July 10	6	100	85	91.5
270	July 5	July 11	6	100	85	93.2
271	July 6	July 12	6	100	85	93.8
272	July 7	July 13	6	100	85	94.7
273	July 8	July 14	6	100	90	96.2
274	July 9	July 15-16	6.7	100	90	94.6
275	July 10	July 16-17	6.2	101	91	93.5
276	July 11	July 17-20	6.5	101	90	93.1
277	July 12	July 18-19	6.1	101	87	92.3
278	July 13	July 19-20	6.1	101	87	91.8
279	July 14	July 20	6	101	87	90.6
280	July 15	July 20-21	5.1	101	87	90.8
281	July 16	July 21	5	101	87	91.8
282	July 17	July 22	5	96	87	93.2
283	July 18	July 23-24	5.6	96	86	92.0

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature Max.	Min.	Mean
	1919					
284	July 19	July 24-25	5.5	96	86	92.0
285	July 20	July 25-26	5.5	97	86	91.8
286	July 21	July 26	5	97	86	91.3
287	July 22	July 27-28	5.5	97	85	91.0
288	July 23	July 28-29	5.3	97	85	91.5
289	July 24	July 29-30	5.4	98	85	92.5
290	July 25	July 30	5	98	85	92.8
291	July 26	July 31	5	98	85	93.1
292	July 27	Aug. 1	5	98	85	93.4
293	July 28	Aug. 2	5	98	91	94.3
294	July 29	Aug. 3-4	5.3	98	90	94.2
295	July 30	Aug. 4	5	97	90	94.2
296	July 31	Aug. 5	5	97	90	94.2
297	Aug. 1	Aug. 6	5	97	90	94.1
298	Aug. 2	Aug. 7	5	97	90	93.8
299	Aug. 3	Aug. 8	5	97	90	93.9
300	Aug. 4	Aug. 9	5	98	90	93.8
301	Aug. 5	Aug. 10	5	98	90	93.6
302	Aug. 6	Aug. 11	5	98	90	93.8
303	Aug. 7	Aug. 12	5	98	88	93.0
304	Aug. 8	Aug. 13	5	98	88	92.5
305	Aug. 9	Aug. 14	5	97	88	92.0
306	Aug. 10	Aug. 15	5	95	88	91.8
307	Aug. 11	Aug. 16	5	95	88	91.5
308	Aug. 12	Aug. 18	6	95	88	92.0
309	Aug. 13	Aug. 19	6	95	85	91.8
310	Aug. 14	Aug. 20	6	95	85	91.5
311	Aug. 15	Aug. 21	6	95	85	90.7
312	Aug. 16	Aug. 22	6	95	84	89.8
313	Aug. 17	Aug. 22-23	5.7	95	81	88.3
314	Aug. 18	Aug. 23-24	5.2	95	81	87.2
315	Aug. 19	Aug. 25	6	92	81	86.7
316	Aug. 20	Aug. 26	6	91	80	86.0
317	Aug. 21	Aug. 27	6	91	80	85.7
318	Aug. 22	Aug. 28	6	91	80	85.9
319	Aug. 23	Aug. 29	6	93	80	87.1
320	Aug. 24	Aug. 29-30	5.2	94	80	88.1
321	Aug. 25	Aug. 30	5	94	80	88.3
322	Aug. 26	Sept. 1	6	95	82	89.5
323	Aug. 27	Sept. 2	6	95	78	89.1
324	Aug. 28	Sept. 3	6	95	77	88.1
325	Aug. 29	Sept. 4	6	95	77	86.9
326	Aug. 30	Sept. 5	6	95	77	85.7
327	Aug. 31	Sept. 6-7	6.7	95	77	84.4
328	Sept. 1	Sept. 8	7	90	77	83.6
329	Sept. 2	Sept. 9	7	90	77	84.0
330	Sept. 3	Sept. 11	8	95	80	85.9
331	Sept. 4	Sept. 12	8	96	80	87.0
332	Sept. 5	Sept. 13	8	97	80	87.5
333	Sept. 6	Sept. 14-16	8.5	97	77	87.1
334	Sept. 7	Sept. 16	9	97	77	87.6
335	Sept. 8	Sept. 17	9	97	77	87.6
336	Sept. 9	Sept. 18	9	97	77	87.4
337	Sept. 10	Sept. 19	9	97	77	87.2
338	Sept. 11	Sept. 20-22	9.5	97	77	87.0
339	Sept. 12	Sept. 21-22	9.2	97	77	86.4
340	Sept. 13	Sept. 22	9	92	77	86.4
*341	Sept. 14	....	....	....	....	....
*342	Sept. 15	....	....	....	....	....
343	Sept. 16	Sept. 23	7	91	76	86.1
344	Sept. 17	Sept. 24	7	91	75	84.8
345	Sept. 18	Sept. 25-26	7.2	91	74	83.1
346	Sept. 19	Sept. 27	8	91	74	82.0
347	Sept. 20	Sept. 28	8	89	74	81.6
348	Sept. 21	Sept. 29	8	92	74	81.6
349	Sept. 22	Sept. 30	8	96	74	81.6
350	Sept. 23	Oct. 1-2	8.8	96	74	83.1
351	Sept. 24	Oct. 2	8	96	74	84.0
352	Sept. 25	Oct. 3	8	96	75	84.8
353	Sept. 26	Oct. 4	8	96	75	86.0
354	Sept. 27	Oct. 5	8	96	80	87.0
355	Sept. 28	Oct. 6	8	96	80	87.2
356	Sept. 29	Oct. 7	8	96	80	86.6
357	Sept. 30	Oct. 7-8	8.3	94	80	86.3
358	Oct. 1	Oct. 9-10	8.9	94	80	86.6
359	Oct. 2	Oct. 10	8	93	80	96.3
360	Oct. 3	Oct. 11	8	93	78	86.1
361	Oct. 4	Oct. 12	8	93	75	84.8

*Incomplete record.

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature Max.	Min.	Mean
	1919					
362	Oct. 5	Oct. 13	8	91	74	83.2
363	Oct. 6	Oct. 14-15	8.8	91	74	81.0
364	Oct. 7	Oct. 15-16	8.2	91	74	80.8
365	Oct. 8	Oct. 17-18	9.1	91	69	78.9
366	Oct. 9	Oct. 18-19	9.6	91	69	77.4
367	Oct. 10	Oct. 20	10	88	69	75.9
368	Oct. 11	Oct. 21	10	88	69	75.5
369	Oct. 12	Oct. 22	10	84	69	75.9
370	Oct. 13	Oct. 23	10	87	69	76.9
371	Oct. 14	Oct. 24	10	90	69	78.2
372	Oct. 15	Oct. 24-25	9.3	90	69	79.3
373	Oct. 16	Oct. 25-26	9.5	90	69	80.1
374	Oct. 17	Oct. 27	10	90	69	81.1
375	Oct. 18	Oct. 28	10	90	70	82.5
376	Oct. 19	Oct. 28-29	9.5	90	72	83.1
377	Oct. 20	Oct. 29-30	9.1	90	73	83.3
378	Oct. 21	Oct. 30	9	90	73	83.9
379	Oct. 22	Oct. 31	9	90	73	83.9
380	Oct. 23	Oct. 31-Nov. 1	8.3	90	73	83.5
381	Oct. 24	Nov. 1-2	8.8	90	73	82.2
382	Oct. 25	Nov. 3	9	90	73	80.7
383	Oct. 26	Nov. 3-4	8.4	90	73	80.0
384	Oct. 27	Nov. 4	8	90	73	78.4
385	Oct. 28	Nov. 5	8	87	72	77.2
386	Oct. 29	Nov. 6	8	87	72	77.1
387	Oct. 30	Nov. 7	8	87	72	77.6
388	Oct. 31	Nov. 8	8	88	72	77.7
389	Nov. 1	Nov. 9	8	94	72	78.4
390	Nov. 2	Nov. 10	8	94	72	79.7
391	Nov. 3	Nov. 10	7	94	72	80.6
392	Nov. 4	Nov. 11	7	94	72	81.2
393	Nov. 5	Nov. 12	7	94	74	81.5
394	Nov. 6	Nov. 13	7	94	74	81.6
395	Nov. 7	Nov. 14	7	94	66	80.8
396	Nov. 8	Nov. 15	7	94	66	80.4
397	Nov. 9	Nov. 16	7	92	66	80.0
398	Nov. 10	Nov. 17	7	84	66	78.0
399	Nov. 11	Nov. 18-20	8.6	83	66	78.1
400	Nov. 12	Nov. 21	9	83	66	78.2
401	Nov. 13	Nov. 22	9	84	66	78.6
402	Nov. 14	Nov. 24	10	86	75	80.0
403	Nov. 15	Nov. 24	9	87	75	80.1
404	Nov. 16	Nov. 25	9	88	75	81.0
405	Nov. 17	Nov. 25-26	8.8	89	75	81.7
406	Nov. 18	Nov. 26	8	89	75	82.0
407	Nov. 19	Nov. 28	9	89	69	80.3
408	Nov. 20	Nov. 29-30	9.3	89	66	79.2
409	Nov. 21	Dec. 1	10	89	66	78.2
410	Nov. 22	Dec. 2	10	89	66	77.4
411	Nov. 23	Dec. 3	10	89	64	76.0
412	Nov. 24	Dec. 4	10	89	64	74.6
413	Nov. 25	Dec. 4-5	9.8	89	64	73.6
414	Nov. 26	Dec. 5	9	80	64	72.3
415	Nov. 27	Dec. 6	9	88	64	72.9
416	Nov. 28	Dec. 6-7	8.8	94	64	74.7
417	Nov. 29	Dec. 7	8	94	64	74.9
418	Nov. 30	Dec. 8	8	94	64	75.9
419	Dec. 1	Dec. 10	9	94	64	77.2
420	Dec. 2	Dec. 11	9	94	64	77.3
421	Dec. 3	Dec. 12	9	94	65	78.7
422	Dec. 4	Dec. 13	9	94	60	78.5
423	Dec. 5	Dec. 14	9	94	60	78.0
424	Dec. 6	Dec. 15	9	94	60	76.0
425	Dec. 7	Dec. 16	9	91	60	74.0
426	Dec. 8	Dec. 18	10	91	60	74.4
427	Dec. 9	Dec. 18	9	89	60	73.5
428	Dec. 10	Dec. 19	9	93	60	74.5
429	Dec. 11	Dec. 20	9	93	60	75.7
430	Dec. 12	Dec. 22	10	93	60	76.2
431	Dec. 13	Dec. 23	10	93	63	77.1
432	Dec. 14	Dec. 24	10	93	63	78.1
433	Dec. 15	Dec. 26	11	93	56	78.0
434	Dec. 16	Dec. 29	13	93	56	78.8
435	Dec. 17	Dec. 30	13	93	56	79.1
436	Dec. 18	Dec. 31	13	93	56	79.4
		1920				
437	Dec. 19	Jan. 2	14	93	56	79.3
438	Dec. 20	Jan. 3	14	88	56	78.7
439	Dec. 21	Jan. 4	14	88	56	78.6

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature		
				Max.	Min.	Mean
	1919					
440	Dec. 22	Jan. 5-6	14.5	88	56	77.9
441	Dec. 23	Jan. 7	15	88	56	77.7
442	Dec. 26	Jan. 8	13	88	71	78.7
443	Dec. 29	Jan. 11	13	88	71	78.2
444	Dec. 30	Jan. 12	13	88	71	77.8
445	Dec. 31	Jan. 13	13	88	71	77.6
	1920					
446	Jan. 5	Jan. 14	9	93	71	77.6
447	Jan. 6	Jan. 15	9	93	72	78.7
448	Jan. 7	Jan. 16	9	95	72	79.8
449	Jan. 8	Jan. 17	9	96	72	81.1
450	Jan. 9	Jan. 18	9	96	74	82.4
451	Jan. 10	Jan. 19	9	96	74	82.7
452	Jan. 11	Jan. 20	9	96	74	84.3
453	Jan. 12	Jan. 21	9	96	74	85.2
454	Jan. 13	Jan. 22-23	9.2	96	70	83.7
455	Jan. 14	Jan. 24	10	96	70	83.5
456	Jan. 15	Jan. 26	11	96	70	81.8
457	Jan. 16	Jan. 27	11	96	70	81.0
458	Jan. 19	Jan. 28	6	90	70	78.2
459	Jan. 20	Jan. 30	10	90	64	76.7
460	Jan. 21	Jan. 31	10	87	64	76.1
461	Jan. 22	Feb. 1	10	91	64	76.9
462	Jan. 23	Feb. 2	10	93	64	77.4
463	Jan. 24	Feb. 3	10	95	64	78.1
464	Jan. 25	Feb. 4	10	95	64	78.8
465	Jan. 26	Feb. 5	10	95	64	79.4
466	Jan. 27	Feb. 6	10	95	64	79.8
467	Jan. 28	Feb. 7	10	95	64	80.5
468	Jan. 29	Feb. 8	10	95	64	80.5
469	Jan. 30	Feb. 9	10	95	70	80.9
470	Jan. 31	Feb. 10	10	95	70	80.5
471	Feb. 1	Feb. 11	10	95	68	79.9
472	Feb. 2	Feb. 12	10	95	68	79.2
473	Feb. 3	Feb. 12-13	9.8	90	68	78.1
474	Feb. 4	Feb. 13	9	90	68	77.7
475	Feb. 5	Feb. 16	11	90	58	75.5
476	Feb. 6	Feb. 16	10	88	58	75.0
477	Feb. 7	Feb. 17	10	88	58	73.8
478	Feb. 8	Feb. 17-18	9.7	88	58	74.0
479	Feb. 9	Feb. 18	9	88	58	73.6
480	Feb. 10	Feb. 19	9	88	58	73.6
481	Feb. 11	Feb. 20	9	84	58	73.8
482	Feb. 12	Feb. 21	9	84	58	73.9
483	Feb. 13	Feb. 22	9	84	58	74.5
484	Feb. 14	Feb. 23	9	84	58	74.9
485	Feb. 15	Feb. 24	9	84	58	75.7
486	Feb. 16	Feb. 25	9	84	67	77.0
487	Feb. 17	Feb. 26	9	84	70	77.3
488	Feb. 18	Feb. 27	9	84	68	76.7
489	Feb. 19	Feb. 28	9	84	65	76.0
490	Feb. 20	March 1	10	82	61	73.8
491	Feb. 24	March 4	9	79	61	70.5
492	Feb. 25	March 5	9	79	61	70.0
493	Feb. 26	March 6	9	79	61	70.0
494	Feb. 27	March 8	10	79	55	67.0
495	Feb. 28	March 10	11	90	55	68.6
496	March 1	March 11	10	90	55	70.3
497	March 2	March 12	10	91	55	72.0
498	March 3	March 13	10	92	55	73.3
499	March 4	March 14	10	92	55	74.5
500	March 5	March 15	10	92	55	75.7
501	March 6	March 16	10	92	55	77.2
502	March 9	March 17	8	92	77	83.0
503	March 10	March 17	7	92	77	83.0
504	March 11	March 18	7	92	77	83.1
505	March 12	March 19	7	92	77	83.1
506	March 15	March 23	8	87	74	81.6
507	March 16	March 24	8	87	74	81.1
508	March 17	March 25	8	87	74	81.2
509	March 18	March 26	8	87	74	81.0
510	March 19	March 28	9	87	74	80.6
511	March 20	March 29	9	87	74	80.4
512	March 21	March 29	8	87	74	80.3
513	March 22	March 30	8	87	75	80.0
514	March 23	March 31	8	87	75	79.1
515	March 24	April 1	8	87	75	79.4
516	March 25	April 1-3	8.5	87	73	78.8
517	March 26	April 4	9	87	73	78.1

Table 2—Duration of Egg Stage—Continued

Lot No.	Laid	Hatched	Average period, days	Temperature Max.	Min.	Mean
	1920					
518	March 27	April 5	9	87	68	76.8
519	March 28	April 6	9	87	68	76.1
520	March 29	April 8	10	87	68	76.3
521	March 30	April 9	10	87	68	77.1
522	March 31	April 10	10	87	68	78.0
523	April 5	April 15	10	85	71	79.4
524	April 8	April 17	9	94	73	81.3
525	April 12	April 20	8	94	73	83.0

The egg cavities were opened carefully at the conclusion of the average period of the egg stage at that season. This interfered least with natural conditions, and since a large number of observations were made it is believed that the average periods as given in Table 2 represent results in which the range of error has been reduced to a minimum.

Temperatures were obtained by the use of a recording thermograph. For each period the single highest temperature and the single lowest temperature are given. The mean temperature is the average of the mean daily temperatures during the period.

From April 23, 1918, to April 12, 1920, over 6,000 observations were made on the duration of the egg stage. The number of individual records were averaged and these data are given below.

The greatest range in the daily periods was from 4.8 to 15 days. The shortest period occurred on June 27, 1918, at a mean temperature of 98.6 degrees F. and the longest period was in December, 1919, with a mean temperature of 77.7 degrees F. The average period of the duration of the egg stage for the year 1919 was 8.7 days. The mean temperature for the year was 83.2 degrees F.

The yearly variations in the duration of the egg stage are shown in Table 3. The influence of the mean temperature on the length of the egg stage is not always definite and the effect of temperatures ranging below the effective temperature is evident.

Table 3 Yearly Variation in Duration of Egg Stage

Date	Period, days	Temperature, mean
May, 1918	6.1	78.4
May, 1919	8.2	84.7
June, 1918	5.1	94.0
June, 1919	6.6	85.2
December, 1918	12.3	81.6
December, 1919	11.2	76.9
January, 1919	11.2	79.1
January, 1920	9.3	79.1

In Table 4 is given a summary of the duration of the egg stage for each month during the period of these studies. It should be noted that all these observations were made in the laboratory, and the periods, especially during the cold season when heat was used, are doubtless considerably shorter than they would be under natural conditions.

Table 4 Summary of Duration of Egg Stage

Month	Temperature, mean	Longest period	Shortest period	Averag period	Collections of eggs observed
1918					
April	72.3	12.4	9.8	11	8
May	78.4	8	4.9	6.1	31
June	94.0	6	4.8	5.1	30
December	81.6	14.1	10	12.3	15
1919					
January	79.1	14.3	9.2	11.2	31
February	78.8	12	8.1	10.1	28
March	80.4	12.5	9	11	31
April	82.4	11.2	8	9.4	30
May	84.7	11	7	8.2	31
June	85.2	8	6	6.6	30
July	92.3	7	5	5.6	31
August	90.8	6.7	5	5.6	31
September	85.1	9.5	7	8.1	28
October	84.5	10	8	8.9	31
November	79.0	10	8	8.5	30
December	76.9	15	9	11.2	27
1920					
January	79.1	11	9	9.3	26
February	76.6	11	9	9.4	25
March	77.0	10	7	8.5	23

Larva

Description.—The newly hatched larva is a delicate, white, legless grub, measuring less than 1 mm. in length. As the larva feeds and molts, the pure white color of the young individual soon becomes modified by dark body contents, which show through the body wall. When full grown, the larva measures from 5 mm. to 8.5 mm. in length. It is sub-cylindrical in shape, and nearly uniform in diameter, except shortly before the posterior end, which tapers to a blunt point. The dorsum and sides are strongly wrinkled, and the entire body is covered with microscopic pubescence. The general color of this stage is soiled white or gray. The mandibles are dark-brown or black. The head is yellowish-brown, small, much narrower than the body, and oval in outline; it is longer than broad, and bears several long scattered hairs. The antennae are located at the lateral angle of the frons. The thoracic segments bear a number of long and rather conspicuous hairs. The legs are represented by enlarged tubercles, each bearing a number of setae. The abdominal segments are well defined, about equal in length, except the last two, which are smaller; each segment bears a few short dorsal and lateral hairs, which are visible only under the microscope. Views of the larva are shown in Figure 3.

Duration of Larval Stage

Observations were made in the laboratory on the duration of the larval stage from May, 1918, to April, 1920. The beginning of this stage was determined accurately by carefully opening the egg cavity as is described in the paragraph on the duration of the egg stage. At the conclusion of the average larval period it was again necessary to disturb the normal conditions by cutting open the larval burrow, in order to ascertain the exact time of pupation. The coverings were then carefully replaced. In many cases as the larva nears maturity it feeds towards the surface of the tuber, leaving only the thin jacket covering the pupal cell, and in such instances the necessary disturbance of natural conditions was reduced to a minimum.

In most cases the tubers contained several larvae, some of which were allowed to develop under normal conditions from egg deposition to pupation, and were not disturbed until the average time of the larval stage had been reached. The results obtained were in most cases approximately the same. All of these periods were averaged and the data obtained are given in Table 5.

Table 5 Duration of Larval Stage

Lot No.	Hatched	Pupated	Average period, days	Temperature		
				Max.	Min.	Mean
	1918	1918				
1	May 5-6	May 20-22	15.7	92	68	79.4
2	May 6	May 21-22	14.6	92	68	80.0
3	May 6-7	May 21-23	15.4	92	68	80.0
4	May 7	May 22-23	14.7	92	68	80.2
5	May 8	May 21-23	14.2	92	68	80.1
6	May 9	May 21-24	13.7	92	68	80.2
7	May 8-9	May 22-23	14	92	68	80.1
8	May 9	May 23	14	92	68	80.1
9	May 9-10	May 24	14.7	92	68	80.2
10	May 9-11	May 23-27	15.4	92	68	80.8
11	May 10	May 24	14	92	68	80.3
12	May 11	May 25	14	89	68	80.2
13	May 11	May 27	16	89	68	80.6
14	May 12	May 27-28	15.7	87	68	80.5
15	May 13	May 28-29	15.4	87	68	80.8
16	May 15	May 29-31	14.8	89	68	81.7
17	May 16	May 30-31	14.7	89	74	82.2
18	May 17	May 31-June 1	14.6	89	74	82.5
19	May 17-18	May 31-June 1	14.7	89	74	82.5
20	May 18-19	June 1-2	14.2	89	74	82.7
21	May 18-20	June 2-4	14.7	89	74	82.5
22	May 20	June 3-4	14.9	89	74	82.6
23	May 21	June 3-5	13.8	89	74	83.0
24	May 22	June 4-5	13.6	89	74	83.1
25	May 23	June 5	13	89	74	83.2
26	May 24	June 6-7	13.4	97	75	84.6
27	May 25	June 7-8	13.4	97	75	85.4
28	May 26	June 8-9	13.6	97	75	85.4
29	May 26-27	June 9-10	13.8	97	75	86.0
30	May 27-28	June 10	13.9	97	75	86.2
31	May 27-28	June 10-12	14.1	100	75	87.5
32	May 29	June 11-12	13.7	100	77	88.0
33	May 30	June 13	14	102	77	88.8
34	May 31	June 14	14	102	77	89.8
35	June 1	June 15	14	102	77	90.7
36	June 3	June 16	13	102	79	92.0
37	June 4	June 18	14	102	81	93.1
38	June 5	June 18	13	103	81	93.8
39	June 6	June 19	13	107	87	94.8
40	June 6	June 19	13	107	87	94.8
41	June 7	June 19-20	12.5	107	87	95.2
42	June 8	June 20	12	107	87	95.4
43	June 9	June 22	13	107	87	95.9
44	June 10	June 23	13	107	87	96.3
45	June 12	June 25-26	13.5	107	89	97.2
46	June 12	June 26	14	107	89	97.2
47	June 13	June 28	15	107	89	97.4
48	June 14	June 28-29	14.5	107	89	97.7
49	June 15	June 30	15	107	89	97.8
50	June 16	July 1	15	107	89	98.2
51	June 17	July 2-3	15.5	107	89	98.1
52	June 18	July 3-4	15.6	107	85	98.0
53	June 19	July 5	16	105	85	97.6
54	June 20	July 6	16	103	85	97.3
55	June 21	July 8	17	103	85	97.2
56	June 22	July 10	18	106	85	97.5
57	June 23	July 11	18	106	85	97.6
58	June 24	July 12-13	18.8	106	85	97.7
59	June 26	July 14	18	106	84	97.2
60	June 26	July 14-15	18.2	106	84	97.3
61	June 27	July 15	18	106	84	97.2
62	June 28	July 16	18	106	84	97.1
63	June 29	July 17	18	106	84	97.1
64	June 30	July 16-18	17	106	84	97.0
65	July 1	July 17-18	16.7	106	84	96.9

Table 5—Duration of Larval Stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature		
				Max.	Min.	Mean
	1918	1918				
66	July 1-2	July 15-19	16	106	84	97.0
67	July 3-4	July 17-19	16.3	106	84	97.3
68	July 4	July 21	17	106	84	97.2
69	July 5	July 22	17	106	84	97.5
		1919				
70	Dec. 26-28	Jan. 20-21	25	95	65	79.3
71	Dec. 28	Jan. 22-23	25.6	95	65	79.6
72	Dec. 29-30	Jan. 22-25	24.3	95	63	79.2
73	Dec. 30-Jan. 1, 1919	Jan. 25-26	24.8	95	63	79.0
74	Dec. 30-Jan. 2, 1919	Jan. 26-27	24.7	95	63	79.0
	1919					
75	Jan. 2-3	Jan. 26-27	24	93	63	78.8
76	Jan. 3	Jan. 27	24	93	63	78.8
77	Jan. 6-7	Jan. 27-28	22.3	93	63	79.3
78	Jan. 7	Jan. 30-31	22.3	93	63	79.6
79	Jan. 7-10	Jan. 28-31	21.3	93	63	79.6
80	Jan. 9-11	Jan. 30-Feb. 2	20.8	93	63	80.1
81	Jan. 10-11	Jan. 31	20.4	93	63	80.2
82	Jan. 11-12	Jan. 31-Feb. 3	20.9	93	63	80.0
83	Jan. 12-15	Feb. 1	19.1	93	63	80.1
84	Jan. 14-16	Feb. 3-9	21.6	93	63	79.3
85	Jan. 14-16	Feb. 4-11	23	93	63	75.5
86	Jan. 15-17	Feb. 5-13	23	93	63	76.6
87	Jan. 16-18	Feb. 6-11	21.5	93	63	79.8
88	Jan. 17-18	Feb. 7-10	21.3	93	63	79.5
89	Jan. 18-19	Feb. 8-10	20.9	93	63	79.2
90	Jan. 19-20	Feb. 9-12	20.6	93	63	79.0
91	Jan. 19-20	Feb. 8-11	20.5	93	63	79.2
92	Jan. 19-22	Feb. 8-10	20.1	93	63	79.6
93	Jan. 20-21	Feb. 8-11	20.4	93	63	79.3
94	Jan. 20	Feb. 10-17	22.4	93	63	80.0
95	Jan. 21-22	Feb. 11-14	21.8	93	63	79.7
96	Jan. 22	Feb. 13-19	24.3	93	63	79.6
97	Jan. 23-24	Feb. 14-27	24.7	93	63	79.4
98	Jan. 24-25	Feb. 15-19	23.5	93	63	79.6
99	Jan. 25-28	Feb. 15-18	22.5	93	65	79.7
100	Jan. 26-28	Feb. 18-25	23.1	93	63	79.4
101	Jan. 27-29	Feb. 17-19	21.3	93	65	79.9
102	Jan. 28	Feb. 17-20	21.1	93	65	80.1
103	Jan. 28-29	Feb. 18-23	22.5	93	63	79.7
104	Jan. 29-30	Feb. 20-24	22.2	93	63	79.5
105	Jan. 30-Feb. 1	Feb. 21-28	24.8	93	63	79.7
106	Jan. 31-Feb. 1	Feb. 24-March 5	25.6	101	63	80.6
107	Jan. 31-Feb. 6	Feb. 25-March 2	24.8	93	63	79.6
108	Feb. 2-5	Feb. 26-March 3	25.3	95	63	79.8
109	Feb. 5-6	Feb. 28-March 3	24.6	95	63	80.3
110	Feb. 7	March 1-4	23.9	101	63	80.8
111	Feb. 7-8	March 2-6	23.2	101	63	81.3
112	Feb. 8-9	March 1-8	22.5	101	63	81.4
113	Feb. 9-13	March 1-8	22.1	101	63	81.4
114	Feb. 11-12	March 3-7	20.4	101	63	81.9
115	Feb. 12-13	March 3-11	19.9	101	63	82.7
116	Feb. 13	March 7-9	22.4	101	63	79.7
117	Feb. 13-14	March 3-5	20.9	101	63	81.8
118	Feb. 13-14	March 3-11	20.4	101	63	81.4
119	Feb. 14-15	March 6-15	22.7	101	63	81.0
120	Feb. 14-16	March 5-15	22.3	101	63	81.0
121	Feb. 16	March 7-16	22.2	101	63	81.0
122	Feb. 17	March 9-12	20.7	101	63	81.0
123	Feb. 17-18	March 9-12	21.3	101	63	81.0
124	Feb. 18-19	March 10-12	22.2	101	63	81.0
125	Feb. 19-20	March 11-16	23.1	101	63	81.0
126	Feb. 19-20	March 12-17	22.6	101	63	81.1
127	Feb. 20-21	March. 14-21	23.1	101	63	80.2
128	Feb. 22	March 14-23	22.6	101	71	80.8
129	Feb. 23-24	March 16-22	22.5	101	71	80.9
130	Feb. 24-25	March 18-24	23.9	101	71	81.0
131	Feb. 25-26	March 21-25	23.8	101	71	80.9
132	Feb. 26-27	March 22-25	23.8	101	71	81.2
133	Feb. 27-March 1	March 22-26	23.5	101	71	80.6
134	March 1-2	March 24-28	23.8	101	71	80.4
135	March 4-8	March 28-April 6	24.5	98	71	79.4
136	March 4	March 29-April 1	25.2	98	71	79.6
137	March 4-6	March 30-April 4	26.1	98	71	79.4
138	March 6-7	March 31-April 4	25.6	90	71	79.3
139	March 7-8	April 1-6	25.7	88	71	78.8
*140	March 7-8					
141	March 8-9	April 2-9	26.7	88	71	79.2

*Incomplete record.

Table 5—Duration of Larval Stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature Max.	Temperature Min.	Temperature Mean
	1919	1919				
142	March 9	April 3-11	25.8	88	71	79.2
143	March 10	April 5-11	26.9	88	71	79.4
144	March 11-14	April 7-9	27.7	88	71	79.3
145	March 12	April 7-12	27.8	90	71	79.4
146	March 12-13	April 9-18	28	95	71	80.1
147	March 14-16	April 8-13	27.8	95	71	79.6
148	March 15-16	April 9-19	28.2	95	71	80.2
149	March 16-17	April 10-16	28	95	71	80.1
150	March 17-19	April 14-20	28.2	95	71	80.3
151	March 18-19	April 13-17	27.5	95	71	80.2
152	March 19-20	April 15-19	26.8	95	71	80.4
153	March 20-22	April 17-18	27.1	95	71	80.5
154	March 22-23	April 17-24	27.5	95	71	81.2
155	March 22-24	April 19-21	27.1	95	71	80.9
156	March 24-25	April 19-20	26.5	95	71	80.9
157	March 25	April 19-21	26	95	71	81.1
158	March 25-26	April 21-25	26.7	95	71	81.5
159	March 26-27	April 22-26	27.4	95	71	81.7
160	March 28	April 23-25	26.7	95	71	82.0
161	March 29-30	April 25-27	26.5	95	71	82.1
162	March 31-April 1	April 25-28	25.7	95	71	82.5
163	March 30-April 1	April 26-28	25.9	95	71	82.4
164	April 2	April 27-28	25.2	95	71	82.8
165	April 3	April 26-30	25.2	95	71	83.2
166	April 3-4	April 28-29	25.1	95	71	83.2
167	April 4-5	April 29-30	25.1	95	71	83.3
168	April 5-6	April 30-May 1	24.8	95	71	83.5
169	April 6	April 27-30	22.7	95	71	83.7
170	April 7	April 29-30	22.7	95	71	83.3
171	April 8	May 1-2	23.3	95	71	83.7
172	April 9	May 1-3	22.5	95	71	83.9
173	April 10	May 2-3	22.5	95	70	84.1
174	April 10-11	May 2-4	22.3	95	70	84.2
175	April 11-12	May 3-4	21.7	95	70	84.4
176	April 12-13	May 3-5	21.2	95	72	84.7
177	April 13	May 4-5	21.1	95	72	84.7
178	April 14	May 4-5	20.3	95	72	84.6
179	April 15	May 5-7	21	93	72	84.4
180	April 16	May 5-6	20.3	93	72	84.6
181	April 17	May 5-7	19	93	75	84.7
182	April 18	May 7-10	21.1	93	75	83.8
183	April 19-20	May 9-10	20.5	93	75	83.4
184	April 20-21	May 10-15	20	93	71	83.3
185	April 22	May 11-14	20	93	71	83.3
186	April 23	May 12-14	19.7	93	71	83.3
187	April 23-24	May 12-15	20	93	71	83.6
188	April 24-25	May 14-17	21	100	71	84.3
189	April 25-26	May 15-17	19.8	100	71	84.3
190	April 25-26	May 16-17	20.4	100	71	84.3
191	April 26-27	May 16-17	19.8	100	71	84.3
192	April 27-28	May 16-17	19.3	100	71	84.4
193	April 28	May 17-21	20.1	100	71	84.5
194	April 28-29	May 19-20	20.1	100	71	84.5
195	April 29	May 20-21	20.1	100	71	84.4
196	April 30-May 1	May 19-21	19.7	100	71	84.5
197	May 1	May 21-24	20.7	100	71	84.7
198	May 2	May 22-23	20.1	100	71	84.6
199	May 3-4	May 22-24	19.9	100	71	84.5
200	May 4	May 23-25	19.9	100	71	84.5
201	May 5	May 24-25	19.5	100	71	84.3
202	May 6	May 24-25	19.1	100	71	84.3
203	May 7	May 25-26	18.2	100	71	84.5
204	May 8	May 26-27	18.7	100	71	84.7
205	May 9	May 27	17.9	100	71	85.1
206	May 10	May 27-28	18.3	100	71	85.7
207	May 11-12	May 28	17.2	100	75	86.3
208	May 12-13	May 28-29	16.1	100	75	86.8
209	May 14	May 29-31	16.7	100	76	86.5
210	May 15-16	June 1	16.1	100	76	86.1
211	May 18	June 3-5	16.3	94	76	84.7
212	May 18	June 3-4	16.1	94	76	85.0
213	May 18	June 4-5	17.5	94	76	84.7
214	May 19	June 5	17.1	94	76	84.5
215	May 19-20	June 4-5	17	94	76	84.5
216	May 20-21	June 5-6	17	94	76	84.4
217	May 21	June 7	17	94	76	84.5
218	May 22	June 8	17.1	100	76	84.9
219	May 23	June 9	17	101	76	85.5
220	May 24	June 9-10	16.2	101	76	85.5

Table 5—Duration of Larval Stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature		
				Max.	Min.	Mean
	1919	1919				
221	May 25	June 10-11	16.1	101	76	85.3
222	May 26	June 10-11	16	101	76	85.5
223	May 26-27	June 11	15.7	101	76	85.5
224	May 28	June 11-12	14.5	101	76	85.8
225	May 29	June 12	14	101	76	85.8
226	May 30-31	June 14-15	14.8	101	76	86.5
227	May 31	June 15	15	101	76	86.7
228	June 1	June 16-17	15.4	101	76	86.6
229	June 1-2	June 16-17	15.8	101	76	86.6
230	June 2	June 17-18	15.5	101	76	86.6
231	June 3	June 18-22	16.3	101	76	87.3
232	June 4	June 19-21	15.6	101	76	87.8
233	June 5	June 20-22	16	101	76	88.1
234	June 7	June 21-22	14.4	101	76	88.7
235	June 8	June 22-23	14.1	101	76	88.3
236	June 9	June 21-24	14.2	96	76	87.8
237	June 10	June 24	14.1	96	76	87.2
238	June 10	June 25-26	15.1	96	76	87.4
239	June 11	June 26-27	15.1	96	80	87.7
240	June 11	June 27	16	96	80	87.7
241	June 12	June 28-29	16.3	95	80	87.7
242	June 13-14	June 29-30	16	95	80	87.8
243	June 14	June 29-30	15.7	94	80	87.7
244	June 15	June 29	14	94	80	88.2
245	June 15-17	June 30-July 1	13.6	96	81	88.7
246	June 17-18	July 1	13.7	96	81	89.2
247	June 19	July 2	13	96	81	89.5
248	June 20	July 3	13	96	81	89.9
249	June 21	July 6-7	13.9	97	81	90.8
250	June 22-23	July 7	14.8	97	83	91.0
251	June 22	July 7-8	15.6	97	84	91.0
252	June 23-24	July 9	15.6	97	84	91.5
253	June 25	July 9	14	97	84	91.9
254	June 26	July 9-10	13.8	97	84	92.2
255	June 27-28	July 10	12.7	98	84	92.6
256	June 28-29	July 10-11	12.2	100	85	93.1
257	June 28-29	July 11	12.4	100	85	93.1
258	June 29-30	July 11-12	11.7	100	85	93.7
259	June 30	July 12-13	12.2	100	85	94.2
260	July 1	July 13-14	12.8	100	85	94.6
261	July 2	July 14-16	13	100	85	94.7
262	July 3	July 16	13	100	85	94.7
263	July 4	July 17	13	101	85	94.8
264	July 5	July 18-19	13.2	101	85	94.4
265	July 6-7	July 19	12.3	101	85	94.5
266	July 7-8	July 19	11.2	101	85	94.7
267	July 8-10	July 19-20	10.3	101	87	95.1
268	July 8-11	July 21	12.2	101	87	95.0
269	July 10	July 22	12	101	87	95.0
270	July 11	July 22-23	11.7	101	87	94.7
271	July 12	July 23-24	12.2	101	86	93.7
272	July 13	July 24-25	12.7	101	86	93.2
273	July 14	July 27-28	13.1	101	86	92.6
274	July 15-16	July 28-29	12.8	101	86	92.7
275	July 16-17	July 30	13.7	101	86	92.6
276	July 17-20	July 30-Aug. 3	14.6	98	86	92.7
277	July 18-19	Aug. 1	14.3	98	86	92.6
*278	July 19-20		...	...	...	...
279	July 20	Aug. 1	12	98	86	92.5
280	July 20-21	Aug. 2-3	13.5	98	86	92.7
*281	July 21		...	...	...	...
282	July 22	Aug. 3-5	13.3	98	86	92.8
283	July 23-24	Aug. 6	14	98	86	93.0
284	July 24-25	Aug. 7	13.5	98	87	93.4
285	July 25-26	Aug. 8	13.5	98	85	93.5
286	July 26	Aug. 8-9	13.2	98	85	93.6
287	July 27-28	Aug. 10	13.4	98	85	93.7
288	July 28-29	Aug. 11	13.2	98	90	93.9
289	July 29-30	Aug. 11	12	98	90	94.0
290	July 30	Aug. 12	13	98	88	93.6
291	July 31	Aug. 12-13	12.8	98	88	93.4
292	Aug. 1	Aug. 13-14	12.5	98	88	93.1
293	Aug. 2	Aug. 10-14	11.3	98	88	93.0
294	Aug. 3-4	Aug. 14	11.3	98	88	93.0
295	Aug. 4	Aug. 15-16	11.4	98	88	92.8
296	Aug. 5	Aug. 16-17	11.6	98	88	92.6
297	Aug. 6	Aug. 18	12	98	88	92.5
298	Aug. 7	Aug. 19	12	98	85	92.2

*Incomplete record.

Table 5—Duration of Larval Stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature		
				Max.	Min.	Mean
	1919	1919				
299	Aug. 8	Aug. 19-20	11.5	98	85	92.0
300	Aug. 9	Aug. 20-21	11.8	97	85	91.4
301	Aug. 10	Aug. 21	11	95	85	91.2
302	Aug. 11	Aug. 22	11	95	84	90.6
303	Aug. 12	Aug. 23	11	95	81	90.0
304	Aug. 13	Aug. 25	12	95	81	89.2
305	Aug. 14	Aug. 26	12	95	80	88.7
306	Aug. 15	Aug. 26-27	11.8	95	80	88.2
307	Aug. 16	Aug. 27-28	11.2	95	80	87.8
308	Aug. 18	Aug. 28-29	11.6	95	80	87.2
309	Aug. 19	Aug. 29-30	11.3	94	80	87.4
310	Aug. 20	Aug. 31	11	94	80	87.4
311	Aug. 21	Sept. 2-3	11.5	95	77	87.0
312	Aug. 22	Sept. 2	11	95	78	87.5
313	Aug. 22-23	Sept. 2-3	11.5	95	77	87.0
314	Aug. 23-24	Sept. 3	11	95	77	87.4
315	Aug. 25	Sept. 4-6	11.6	95	77	86.7
316	Aug. 26	Sept. 5	10	95	77	87.0
317	Aug. 27	Sept. 6	10	95	77	86.8
318	Aug. 28	Sept. 8-9	12.2	95	77	86.3
319	Aug. 29	Sept. 11-12	13.3	96	77	87.0
320	Aug. 29-30	Sept. 13-15	15.7	97	77	86.8
321	Aug. 30	Sept. 16	17	97	77	86.4
322	Sept. 1	Sept. 16-18	15.6	97	77	85.8
323	Sept. 2	Sept. 17	15	97	77	86.0
324	Sept. 3	Sept. 18	15	97	77	86.2
325	Sept. 4	Sept. 19	15	97	77	86.5
326	Sept. 5	Sept. 20	15	97	77	86.8
327	Sept. 6-7	Sept. 20-21	14.7	97	77	87.1
328	Sept. 8	Sept. 21-22	13.2	97	77	87.5
329	Sept. 9	Sept. 22	13	97	77	87.5
330	Sept. 11	Sept. 22-23	11.8	97	77	86.5
331	Sept. 12	Sept. 23	11	97	77	86.0
332	Sept. 13	Sept. 24	11	92	75	84.8
333	Sept. 14-16	Sept. 24-28	12.3	91	74	83.5
334	Sept. 16	Sept. 26-27	11.2	91	74	83.0
335	Sept. 17	Sept. 28-29	11.7	91	74	83.5
336	Sept. 18	Sept. 30	12	96	74	83.7
337	Sept. 19	Oct. 3-4	14.5	96	74	84.3
338	Sept. 20-22	Sept. 30-Oct. 6	14.1	96	74	84.4
339	Sept. 21-22	Oct. 6-10	16.5	96	74	84.4
340	Sept. 22	Oct. 8-10	16.8	96	74	84.4
*341						
*342						
343	Sept. 23	Oct. 8	15	96	74	84.2
344	Sept. 24	Oct. 10-14	16.8	96	74	83.6
345	Sept. 25-26	Oct. 8-15	16.7	96	74	83.4
346	Sept. 27	Oct. 15-16	18.2	96	74	83.7
347	Sept. 28	Oct. 17	19	96	73	83.4
348	Sept. 29	Oct. 18	19	96	69	82.5
349	Sept. 30	Oct. 17-20	19.2	94	69	81.3
350	Oct. 1-2	Oct. 22-23	21	94	69	81.0
351	Oct. 2	Oct. 21-24	20.2	94	69	81.0
352	Oct. 3	Oct. 23-25	20.5	93	69	81.1
353	Oct. 4	Oct. 24-25	20.2	93	69	80.8
354	Oct. 5	Oct. 25	20	93	69	80.5
355	Oct. 6	Oct. 26	20.2	91	69	80.5
356	Oct. 7	Oct. 26-28	20	91	69	80.9
357	Oct. 7-8	Oct. 27-30	20.4	91	69	80.2
358	Oct. 9-10	Oct. 29-31	20	91	69	81.3
359	Oct. 10	Oct. 30-31	20.8	90	69	80.0
360	Oct. 11	Oct. 31-Nov. 3	21.5	90	69	79.2
361	Oct. 12	Oct. 31-Nov. 1	21.3	90	69	79.7
362	Oct. 13	Nov. 1-3	21.1	90	69	79.5
363	Oct. 14-15	Nov. 5-8	23.6	90	69	79.4
364	Oct. 15-16	Nov. 7-8	23.5	90	69	79.6
365	Oct. 17-18	Nov. 9-10	23.7	94	69	80.2
366	Oct. 18-19	Nov. 10-11	22.6	94	70	80.6
367	Oct. 20	Nov. 11	22	94	72	81.4
368	Oct. 21	Nov. 12	22	94	72	81.3
369	Oct. 22	Nov. 13-14	22.3	94	66	80.9
370	Oct. 23	Nov. 13-15	22.2	94	66	80.6
371	Oct. 24	Nov. 14-15	22.4	94	66	80.4
372	Oct. 24-25	Nov. 16	22.8	94	66	80.2
373	Oct. 25-26	Nov. 17	22.5	94	66	79.8
374	Oct. 27	Nov. 18	22	94	66	79.1
375	Oct. 28	Nov. 18	21	94	66	79.0

*Incomplete record.

Table 5—Duration of Larval Stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature Max.	Min.	Mean
	1919	1919				
376	Oct. 28-29	Nov. 18-19	22.3	94	66	79.0
377	Oct. 29-30	Nov. 19	20.9	94	66	79.0
378	Oct. 30	Nov. 20	21	94	66	79.0
379	Oct. 31	Nov. 20-21	20.2	94	66	79.0
380	Oct. 31-Nov. 1	Nov. 21	20.8	94	66	79.0
381	Nov. 1-2	Nov. 21-22	20.1	94	66	79.0
382	Nov. 3	Nov. 24	21	94	66	79.7
*383	Nov. 3-4	....	....	....	....	....
384	Nov. 4	Nov. 25	21	94	66	80.1
385	Nov. 5	Nov. 26-Dec. 3	22.3	94	64	78.5
386	Nov. 6	Nov. 28-30	22.6	94	66	79.5
387	Nov. 7	Dec. 1-4	26.3	94	64	78.2
388	Nov. 8	Dec. 4	26	94	64	78.1
389	Nov. 9	Dec. 5	26	92	64	77.6
390	Nov. 10	Dec. 6	26	88	64	77.4
391	Nov. 10	Dec. 6	26	88	64	77.4
392	Nov. 11	Dec. 8	27	94	64	77.8
393	Nov. 12	Dec. 8	26	94	64	77.8
394	Nov. 13	Dec. 9	26	94	60	78.0
395	Nov. 14	Dec. 10	26	94	60	78.1
396	Nov. 15	Dec. 11	26	94	60	77.9
397	Nov. 16	Dec. 12	26	94	60	78.0
398	Nov. 17	Dec. 13	26	94	60	77.6
399	Nov. 18-20	Dec. 18	28.4	94	60	76.7
400	Nov. 21	Dec. 19	28	94	60	76.7
401	Nov. 22	Dec. 20	28	94	60	76.9
402	Nov. 24	Dec. 22	28	94	60	76.6
403	Nov. 24	Dec. 23	29	94	60	76.8
404	Nov. 25	Dec. 24	29	94	60	76.5
405	Nov. 25-26	Dec. 24-25	28.3	94	60	76.4
406	Nov. 26	Dec. 25	29	94	60	76.1
407	Nov. 28	Dec. 26-27	28.5	94	56	76.0
408	Nov. 29-30	Dec. 27	27.7	94	56	76.0
409	Dec. 1	Dec. 29	28	94	56	76.6
410	Dec. 2	Dec. 30	28	94	56	77.0
411	Dec. 3	Dec. 31	28	94	56	76.9
		1920				
412	Dec. 4	Jan. 1	28	94	56	78.1
413	Dec. 4-5	Jan. 2	28.2	94	56	78.1
414	Dec. 5	Jan. 3	29	94	56	78.0
415	Dec. 6	Jan. 4	29	94	56	77.9
416	Dec. 6-7	Jan. 4-5	28.2	94	56	77.8
417	Dec. 7	Jan. 5-6	28.2	93	56	77.3
418	Dec. 8	Jan. 6	29	93	56	77.2
419	Dec. 10	Jan. 7	28	93	56	77.0
420	Dec. 11	Jan. 7-8	27.6	93	56	77.1
421	Dec. 12	Jan. 8	27	93	56	77.4
422	Dec. 13	Jan. 9-10	28.2	93	56	76.8
423	Dec. 14	Jan. 10-11	28.1	93	56	77.9
424	Dec. 15	Jan. 11-12	27.8	93	56	78.4
425	Dec. 16	Jan. 13	28	93	56	78.8
426	Dec. 18	Jan. 14-15	27.5	93	56	79.2
427	Dec. 18	Jan. 16	29	95	56	79.5
428	Dec. 19	Jan. 17	29	96	56	79.6
429	Dec. 20	Jan. 18-19	29.8	96	56	79.9
430	Dec. 22	Jan. 20	29	96	56	79.7
431	Dec. 23	Jan. 21	29	96	56	79.6
432	Dec. 24	Jan. 22-23	29.2	96	56	79.7
433	Dec. 26	Jan. 24	29	96	56	80.3
434	Dec. 29	Jan. 26	28	96	70	80.1
435	Dec. 30	Jan. 27	28	96	70	79.9
436	Dec. 31	Jan. 27-28	27.2	96	70	79.6
	1920					
437	Jan. 2	Jan. 28	26	96	70	79.4
438	Jan. 3	Jan. 29	26	96	64	79.3
439	Jan. 4	Jan. 30	26	96	64	79.2
440	Jan. 5-6	Jan. 30	24.4	96	64	79.3
441	Jan. 7	Feb. 2	26	96	64	80.0
442	Jan. 8	Feb. 3	26	96	64	80.3
443	Jan. 11	Feb. 5	25	96	64	80.8
444	Jan. 12	Feb. 6	25	96	64	81.0
445	Jan. 13	Feb. 7	25	96	64	81.0
446	Jan. 14	Feb. 9	26	96	64	80.5
447	Jan. 15	Feb. 10	26	96	64	80.2
448	Jan. 16	Feb. 10-11	25.6	96	64	80.0
449	Jan. 17	Feb. 10	24	96	64	79.7
*450	Jan. 18	....	....	....	....	....
451	Jan. 19	Feb. 12	24	95	64	79.0

*Incomplete record.

Table 5—Duration of larval stage—Continued

Lot	Hatched	Pupated	Average period, days	Temperature Max.	Temperature Min.	Temperature Mean
	1920	1920				
452	Jan. 20	Feb. 12-18	26	95	58	77.2
453	Jan. 21	Feb. 18	28	95	58	76.8
454	Jan. 22-23	Feb. 19-20	28.2	95	58	76.9
455	Jan. 24	Feb. 21	28	95	58	76.9
456	Jan. 26	Feb. 22	27	95	58	77.2
457	Jan. 27	Feb. 22-23	26.5	95	58	77.3
458	Jan. 28	Feb. 23	26	95	58	77.4
459	Jan. 30	Feb. 26	27	95	58	77.4
460	Jan. 31	Feb. 26	26	95	58	77.3
461	Feb. 1	Feb. 27	26	95	58	76.8
462	Feb. 2	Feb. 28	26	95	58	76.3
463	Feb. 3	March 1	27	90	58	75.3
464	Feb. 4	March 2	27	90	58	74.8
465	Feb. 5	March 4	28	90	58	74.4
466	Feb. 6	March 6	29	88	58	73.5
467	Feb. 7	March 7	29	88	58	73.0
468	Feb. 8	March 8	29	88	55	72.4
469	Feb. 9	March 10	30	90	55	72.5
470	Feb. 10	March 12	31	91	55	73.1
471	Feb. 11	March 13	31	92	55	73.4
472	Feb. 12	March 14	31	92	55	73.6
473	Feb. 12-13	March 14-15	31	92	55	73.8
474	Feb. 13	March 15	31	92	55	73.8
475	Feb. 16	March 14-18	30.5	92	55	75.0
476	Feb. 16	March 18-19	30.6	92	55	75.3
477	Feb. 17	March 20	32	92	55	75.6
478	Feb. 17-18	March 21-22	32.6	92	55	75.8
479	Feb. 18	March 22	33	92	55	75.8
480	Feb. 19	March 23-24	33.3	92	55	76.0
481	Feb. 20	March 25-26	34.2	92	55	76.6
482	Feb. 21	March 27-28	35.5	92	55	76.5
483	Feb. 22	March 28	35	92	55	76.4
484	Feb. 23	March 29	35	92	55	76.4
485	Feb. 24	March 30	35	92	55	76.3
486	Feb. 25	March 31-April 1	35.5	92	55	76.4
487	Feb. 26	April 1-2	35.6	92	55	76.6
488	Feb. 27	April 2	35	92	55	76.7
489	Feb. 28	April 3	35	92	55	76.9
480	March 1	April 4	34	92	55	77.5
491	March 4	April 5-6	32.5	92	55	77.7
492	March 5	April 6-7	32.5	92	55	78.0
493	March 6	April 8	33	92	55	78.5
494	March 8	April 9	32	92	62	79.8
495	March 10	April 10	31	92	68	80.0
496	March 11	April 10	30	92	68	80.0
*497	March 12					
498	March 13	April 9	27	92	68	79.5
499	March 14	April 10	27	87	68	79.4
500	March 15	April 11	27	87	68	79.5
501	March 16	April 12	27	87	68	79.5
502	March 17	April 13	27	87	68	79.4
503	March 17	April 13	27	87	68	79.4
504	March 18	April 14	27	87	68	79.0
505	March 19	April 15	27	87	68	78.9
506	March 23	April 16	24	87	68	78.8
507	March 24	April 17	24	94	68	79.1
508	March 25	April 18	24	94	68	79.5
509	March 26	April 19	24	94	68	79.6
510	March 28	April 22	25	94	68	80.1
511	March 29	April 23	25	94	68	80.3
512	March 29	April 23	25	94	68	80.3
513	March 30	April 24	25	94	68	80.7
514	March 31	April 25	25	94	68	81.1
*515	April 1					
516	April 1-3	April 26-27	23.8	94	68	81.0
517	April 4	April 28	24	94	68	81.1
518	April 5	April 29	24	94	71	81.5
519	April 6	April 30	24	94	73	81.8
520	April 8	May 1	23	94	73	81.3
521	April 9	April 30	21	94	73	82.1
522	April 10	May 1	21	94	73	82.2
523	April 15	April 30-May 1	15.3	94	73	83.0
524	April 17	May 3-4	16.6	94	73	83.5
525	April 20	May 6	16	94	73	83.8

*Incomplete record.

A thermograph was used to record the existing temperatures during the time of observation. For each period the single highest temperature and the single lowest temperature are given. The mean temperature given is the average of the daily mean temperatures during the period.

The shortest larval period, 10 days, occurred twice during August, 1919. The mean temperatures during these periods ranged from 86.8 to 87 degrees F. The longest larval period was 35.6 days. It occurred from February 26, 1920 to April 2, 1920. The mean temperature during this period was 76.6 degrees F.

The yearly variation in the duration of the larval stage is shown in Table 6. The effect of the mean temperature on the length of the stage is apparent. During the winter months the period is more variable. A slight decrease in the mean temperature usually results in a considerable increase in the length of the period.

Table 6 Yearly Variation in Duration of Larval Stage

Date	Period, days	Temperature, mean
May, 1918	14.3	78.4
May, 1919	17.1	84.7
June, 1918	15.3	94.0
June, 1919	14.4	85.2
December, 1918	24.8	81.6
December, 1919	28.3	76.9
January, 1919	22.2	79.1
January, 1920	26.0	79.1

A summary of the duration of the larval stage from May, 1918 to April, 1920 is given in Table 7. The longest period and the shortest period for each month are given, together with the average period for the month. The average monthly period is the sum of the daily observations divided by the number of collections of larvae on which notes were taken during the month.

Table 7 Summary of Duration of Larval Stage

Month	Temperature, mean	Longest period	Shortest period	Average period	Collections of larvae observed
1918					
May	78.4	16	13	14.3	34
June	94.0	18.8	12	15.3	30
December	81.6	25.6	24.3	24.8	5
1919					
January	79.1	25.6	19.1	22.2	33
February	78.8	25.3	19.9	22.5	26
March	80.4	28.2	23.8	26.6	29
April	82.4	25.2	19	21.4	33
May	84.7	20.7	14	17.1	31
June	85.2	16.3	11.7	14.4	32
July	92.3	14.6	10.3	12.8	30
August	90.8	17	10	11.8	30
September	85.1	19.2	11	14.7	26
October	84.5	23.7	20	21.4	31
November	79.0	29	20.1	26.1	27
December	76.9	29.8	27	28.3	28
1920					
January	79.1	28.2	24.4	26	23
February	76.6	35.6	26	31.1	29
March	77.0	34	24	27.6	24
April	80.7	23.8	14.3	20.7	10

For the entire observations the longest period and the shortest period averaged 24 and 18.6 days, respectively. The mean temperature for the period over which the records were made averaged 82.4 degrees F.

Prepupal Stage

The duration of this stage usually extends from one to several days. It is characterized by the larva's becoming shorter and distended, with the wrinkles on the body more exaggerated. The thoracic region is greatly thickened, and the legs are represented by enlarged swellings. During this stage the larva remains quiet, but if disturbed, exhibits about the same degree of activity as the pupa. The head is much narrower than the thorax and abdomen, and is yellowish-brown in color. The thorax and abdomen are white in color, the latter being modified somewhat in some specimens by dark abdominal contents, which show through the transparent body walls. The average length of this stage is about 5.5 mm.

Pupation

The adult appendages are formed completely within the last larval skin, and the first external indication of pupation is the splitting of the head shield at the suture between the eyes, and skin on the dorsum of the thorax. Through this split soon appears the white head and thorax of the pupa. The head shield is pushed backward over the head and beak on the ventral side of the thorax. At this time the antennae are geniculate with the distal portion bent posteriorly; however, they soon straighten out and are almost in normal position by the time pupation has been completed. When the head, beak, and thorax are exposed, the last larval skin is slowly pushed backward over the tip of the abdomen by a series of body contractions and vigorous twistings and lateral movements. The newly transformed pupa is fully developed, and clear white in color. The cast skin sometimes remains attached to the tip of the abdomen for a brief period, but normally it is cast off completely during the process of pupation. The head shield remains attached to the cast larval skin. The time required for pupation varies considerably and on the average consumes thirty to forty-five minutes.

Pupa

Description.—The pupa is at first white, but shortly before its transformation to the adult, it becomes yellowish and then gradually grows darker in color.

Ventral view: Elongate, tapering to a blunt point posteriorly, broadly rounded anteriorly. Head and beak elongate, folded down upon the thorax. The beak robust and extends between the first pair of legs slightly beyond the first tarsal joint. Both head and beak bear several pairs of minute tubercles with long slender bristles or hairs. The eyes at first colorless, but grow darker with age, and become dark-brown or almost black before transformation to adult. The antennae extend anteriorly towards and beyond the dorsum, not folded; the segments distinct, and the last one bears numerous minute tubercles. The legs not folded, lying closely upon the body, and extending posteriorly. The first two pairs plainly visible, with the segments distinct. The hind pair covered by the wing pads except the tarsal joints, which reach to the base of the seventh abdominal segment. The abdomen is mobile. On the distal end two prominent pointed prongs directed posteriorly and curved outward. These processes assist in the rather limited lateral movements which the pupa is able to make. The abdominal segments distinct and become smaller posteriorly; all strongly wrinkled; on the lateral margin of each segment prominent tubercles bearing short hairs.

Lateral view: The dorsum gently convex when pupa is in natural position. The head deflexed. Thoracic segments distinct, all bearing tuberculate hairs on dorsum. Prothorax strongly convex on dorsum, prominent; antennae and first two pairs of legs situated closely upon sides of the thorax and extending diagonally to the body. Several short hairs on the knees of each pair of legs. The tips of the antennae extending above the dorsum of thorax. Elytra striate. Wings prominent, directed backward and downward, extending between the second and third pair of legs. The last pair, except the knees and tarsi, entirely covered by the wings. Abdominal segments distinct, wrinkled on the dorsum, with many small tubercles on each segment bearing short hairs. Spiracles not conspicuous.

Dorsal view: Head with eight long hairs, each originating from a minute tubercle. Front margin of prothorax with four similar hairs, and several short discal bristles on mesothorax. Tips of the antennae on each side of prothorax prominent. The knees of all legs plainly visible; the last pair between the wings and body. Abdominal segments become smaller posteriorly; each with a discal row of very small tubercles bearing setae of varying lengths. Views of the pupa are shown in Figure 3.

The pupa averages about 5 mm. in length, and 1.5 mm. in width. Measurements of twenty individuals are given in Table 8.

Table 8 Measurements of Pupa

	Length, mm.	Width, mm.
Average	5.2	1.6
1	5.5	1.5
2	5.2	1.5
3	5.0	1.2
4	5.2	1.5
5	4.8	1.4
6	5.7	2.0
7	5.0	1.5
8	4.5	1.4
9	5.5	1.8
10	5.5	2.0
11	5.5	2.0
12	5.0	1.7
13	5.2	1.3
14	5.5	1.5
15	5.5	2.0
16	4.5	1.5
17	5.5	2.0
18	5.0	1.6
19	5.3	1.4
20	5.2	1.5

Duration of the Pupal Stage

It was determined that the pupa would complete its development if removed from the pupal cell and kept in a small tin box containing a bit of moistened cotton. The observations on the length of the pupal stage made in this manner did not vary greatly from those where the pupa was allowed to develop within the tuber. The former method, however, does not include the time elapsing from transformation to adult emergence. All observations given here on the length of the pupal stage were made on pupae within the tuber, and the termination of the stage was considered as the emergence of the adult. This makes the stage slightly longer on the average, but gives the exact time required from egg deposition to appearance of the adult of the next generation.

The data obtained in laboratory observations from May, 1918 to May, 1920, are given in Table 9. It will be noted that there is considerable variation in the length of this stage during some seasons. This is very likely caused by varying effective temperatures and the condition of the tubers. The longest pupal period, 27.8 days, was noted in December, 1919, with a mean temperature of 76.9 degrees F. The maximum temperature and the minimum temperature that occurred during this period were 96 and 56 degrees F., respectively. The shortest pupal period, 7 days, occurred in May, 1918. The mean for this period was 82.3 degrees F.

Table 9 Duration of Pupal Stage

Lot No.	Pupated	Emerged	Average period, days	Temperature		
				Max.	Min.	Mean
	1918	1918				
1	May 20-22	May 27-29	7	87	74	82.3
2	May 21-22	May 29-June 2	9	89	74	83.1
3	May 21-23	May 30-31	9	89	74	82.8
4	May 22-23	May 30-June 1	9.2	89	74	83.1
5	May 21-23	May 30-31	9.4	89	74	82.8
6	May 21-24	May 30-June 2	9.2	89	74	83.1
7	May 22-23	June 3	11.3	89	74	83.2
8	May 23	June 1-3	10	89	74	83.3
9	May 24	June 1-2	8.7	89	75	83.6
10	May 23-27	June 2-4	9.7	89	74	83.2
11	May 24	June 2-3	9.5	89	75	83.5
12	May 25	June 3-7	10	89	75	83.5
13	May 27	June 3-10	9.2	97	77	86.8
14	May 27-28	June 3-10	9.8	97	77	86.8
15	May 28-29	June 5-10	9.8	97	77	87.3
16	May 29-31	June 6-10	9.6	97	77	87.7
17	May 30-31	June 7-16	11.1	102	77	90.1
18	May 31-June 1	June 9-12	9.8	100	77	88.9
19	May 31-June 1	June 10-12	10.3	100	77	88.9
20	June 1-2	June 10-11	8.8	98	77	88.5
21	June 2-4	June 11-16	10.1	102	77	91.3
22	June 3-4	June 11-18	9.5	102	79	91.0
23	June 3-5	June 11-19	11.4	107	81	91.8
24	June 4-5	June 14-23	11.8	107	81	94.6
25	June 5	June 13-21	11.7	107	81	94.9
26	June 6-7	June 15-20	10.4	107	87	95.2
27	June 7-8	June 16-21	10.4	107	87	95.5
28	June 8-9	June 16-25	9.7	107	87	96.2
29	June 9-10	June 16-23	9.9	107	87	96.1
30	June 10	June 17-22	9.1	107	87	96.0
31	June 10-12	June 18-22	9.1	107	87	96.0
32	June 11-12	June 18-25	9.4	107	88	96.9
33	June 13	June 18-24	9	107	89	97.1
34	June 14	June 22-24	9	107	89	97.4
35	June 15	June 21-25	8.5	107	89	97.6
36	June 16	June 21-26	7.6	107	89	98.0
37	June 18	June 26-27	8.7	107	93	98.8
38	June 18	June 27-29	9.7	107	93	98.7

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature Max.	Temperature Min.	Temperature Mean
	1918	1918				
39	June 19	June 29-30	10.2	105	93	98.5
40	June 19	June 29-30	10.2	105	93	98.5
41	June 19-20	June 29	9.6	105	93	98.5
42	June 20	June 29-July 4	11.3	103	85	97.7
43	June 22	July 2-7	12	103	85	97.2
44	June 23	July 4-7	12.4	103	85	97.0
45	June 25-26	July 5-9	11.3	103	85	97.0
46	June 26	July 7-14	13.3	106	84	97.2
47	June 28	July 7-13	12	106	85	96.1
48	June 28-29	July 9-11	11.5	106	85	97.2
49	June 30	July 8-15	11.6	106	84	97.1
50	July 1	July 9-13	10.4	106	85	97.2
51	July 2-3	July 12-25	16.1	106	84	97.3
52	July 3-4	July 14-27	15	106	84	97.4
53	July 5	July 13-18	11.8	106	84	97.5
54	July 6	July 15-23	12.6	106	84	97.7
55	July 8	July 15-18	8	106	84	98.0
56	July 10	July 17-25	9.8	105	84	96.2
57	July 11	July 18-27	11.2	105	84	97.5
58	July 12-13	July 22-28	11.3	105	84	97.4
59	July 14	July 20-23	10	105	90	97.6
60	July 14-15	July 23-Aug. 1	14	105	88	97.3
*61	July 15	....	....	....	....	....
*62	July 16		....	....	....	....
63	July 17	July 24-Aug. 11	14	105	88	96.8
64	July 16-18	July 24-31	10.3	105	88	96.0
65	July 17-18	July 25-Aug. 1	11	105	88	96.0
66	July 15-19	July 25-27	9	105	90	97.6
67	July 17-19	July 31-Aug. 3	9.8	105	88	97.4
68	July 21	July 30-31	9.5	102	88	97.5
69	July 22	July 29-Aug. 3	8.7	103	88	97.4
	1919	1919				
70	Jan. 20-21	Feb. 1-10	10.5	93	63	79.5
71	Jan. 22-23	Feb. 4-8	14.3	93	63	79.5
72	Jan. 22-25	Feb. 7-15	17.1	93	63	79.6
73	Jan. 25-26	Feb. 9-16	17.3	93	65	79.6
74	Jan. 26-27	Feb. 10-13	16.7	93	65	79.2
75	Jan. 26-27	Feb. 10-14	15.8	93	65	79.7
76	Jan. 27	Feb. 11-14	16.7	93	65	79.8
77	Jan. 27-28	Feb. 12-14	16	93	65	79.8
78	Jan. 30-31	Feb. 12-16	16	93	65	79.9
79	Jan. 28-31	Feb. 13-18	15.9	93	65	80.2
80	Jan. 30-Feb. 2	Feb. 13-17	15	93	65	80.2
81	Jan. 31	Feb. 14-17	15	93	65	79.9
82	Jan. 31-Feb. 3	Feb. 16-18	15	93	65	79.8
83	Feb. 1	Feb. 17-21	16.9	93	65	79.5
84	Feb. 3-9	Feb. 17-20	12.8	93	65	79.8
85	Feb. 4-11	Feb. 20-27	15.5	93	63	79.0
86	Feb. 5-13	Feb. 20-23	14.3	93	63	79.7
87	Feb. 6-11	Feb. 20-25	14.5	93	63	79.5
88	Feb. 7-10	Feb. 19-24	14.3	93	63	79.4
89	Feb. 8-10	Feb. 22-25	14.8	93	63	79.4
90	Feb. 9-12	Feb. 22-26	15.5	93	63	79.6
91	Feb. 8-11	Feb. 24-27	16.4	93	63	79.7
92	Feb. 8-10	Feb. 25-26	16.5	93	63	79.6
93	Feb. 8-11	Feb. 25-28	17	93	63	79.8
94	Feb. 10-17	Feb. 26-March 3	15.9	93	63	80.5
95	Feb. 11-14	Feb. 28-March 3	17.4	93	63	80.7
96	Feb. 13-19	March 1-5	15.4	101	63	81.8
97	Feb. 14-27	March 2-9	17.1	101	63	81.5
98	Feb. 15-19	March 4-7	15.9	101	63	81.8
99	Feb. 15-18	March 5-10	17.5	101	63	81.2
100	Feb. 18-25	March 5-9	15.7	101	63	81.6
101	Feb. 17-19	March 4-12	17.5	101	63	81.0
102	Feb. 17-20	March 7-11	17.5	101	63	81.0
103	Feb. 18-23	March 7-14	17.2	101	63	80.9
104	Feb. 20-24	March 8-23	17.5	101	63	80.5
105	Feb. 21-28	March 8-15	14.5	101	63	80.9
106	Feb. 24-March 5	March 8-16	15.4	101	72	82.2
107	Feb. 25-March 2	March 9-16	14.4	101	72	82.2
108	Feb. 26-March 3	March 9-16	14.5	101	72	82.2
109	Feb. 28-March 3	March 16	14.5	101	72	82.2
110	March 1-4	March 16-22	16.2	101	71	81.2
111	March 2-6	March 16-25	18	101	71	80.9
112	March 1-8	March 16-25	17.7	101	71	80.9
113	March 1-8	March 16-24	16.2	101	71	81.0
114	March 3-7	March 15-20	15	101	72	80.9
115	March 3-11	March 17-24	66.1	101	71	80.5

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature Max.	Min.	Mean
	1919	1919				
116	March 7-9	March 21-30	16.1	88	71	78.8
117	March 3-5	March 17-28	18	101	71	80.0
118	March 3-11	March 20-30	19.9	101	71	80.0
119	March 6-15	March 24-April 2	19.4	90	71	79.1
120	March 5-15	March 25-April 2	19.5	90	71	79.2
121	March 7-16	March 26-31	18.2	88	71	79.0
122	March 9-12	March 26-April 3	17.9	88	71	79.0
123	March 9-12	March 28-April 4	19	88	71	78.7
124	March 10-12	March 29-30	18.4	88	71	78.9
125	March 11-16	March 29-April 1	17.9	88	71	79.1
126	March 12-17	March 30-April 6	19.1	88	71	78.8
127	March 14-21	March 31-April 9	19.6	88	71	79.4
128	March 14-23	April 4-11	21.1	88	70	79.3
129	March 16-22	April 1-8	18.7	88	71	79.1
130	March 18-24	April 7-14	20.2	95	70	79.8
131	March 21-25	April 8-13	19.7	93	70	79.9
132	March 22-25	April 9-14	19.2	95	70	80.2
133	March 22-26	April 9-16	19.6	95	70	80.5
134	March 24-28	April 12-16	18.8	95	70	80.7
135	March 28-April 6	April 13-20	17.4	95	70	81.5
136	March 29-April 1	April 14-19	18.2	95	70	81.3
137	March 30-April 4	April 16-24	18.1	95	70	82.1
138	March 31-April 4	April 16-23	17.9	95	70	82.0
139	April 1-6	April 17-25	18	95	70	82.3
*140	....	....	....	....	....	....
*141	April 2-9	....	....	....	....	....
142	April 3-11	April 24-26	19.2	95	70	83.0
143	April 5-11	April 23-28	18.2	95	70	83.5
144	April 7-9	April 26-27	18.4	95	70	83.3
145	April 7-12	April 27	18.4	95	70	83.3
146	April 9-18	April 28	18.5	95	70	83.5
147	April 8-13	April 27-29	16.5	95	70	83.7
148	April 9-19	April 27-30	16	95	70	83.7
149	April 10-16	April 29-30	16	95	70	83.9
150	April 14-20	April 29-May 2	16.3	93	72	84.1
151	April 13-17	April 30-May 2	16	95	72	84.3
152	April 15-19	May 1-2	15.7	93	72	84.1
153	April 17-18	May 1-9	17.3	93	75	84.0
154	April 17-24	May 2-6	15.8	93	75	84.9
155	April 19-21	May 2-10	14.6	93	75	83.9
156	April 19-20	May 4-7	15.3	93	75	84.9
157	April 19-21	May 4-9	15.8	93	75	84.2
158	April 21-25	May 5-6	14.5	93	76	84.6
159	April 22-26	May 7-11	13.3	93	71	83.3
160	April 23-25	May 6-14	14.8	94	71	83.3
161	April 25-27	May 7-11	13	93	71	83.2
162	April 25-28	May 8-10	13	93	75	83.7
163	April 26-28	May 9-16	16	97	71	83.9
164	April 27-28	May 9-14	15	94	71	83.2
165	April 26-30	May 9-17	14	100	71	84.3
166	April 28-29	May 10-16	14.7	97	71	83.1
167	April 29-30	May 10-20	15.4	100	71	84.4
168	April 30-May 1	May 10-17	14.1	100	71	84.1
169	April 27-30	May 10-17	15.8	100	71	84.4
170	April 29-30	May 12-18	15.3	100	71	84.3
171	May 1-2	May 13-28	15.5	100	71	84.8
172	May 1-3	May 15-18	15.7	100	71	84.5
173	May 2-3	May 17-21	16	100	71	84.5
174	May 2-4	May 15-24	15.3	100	71	84.7
175	May 3-4	May 14-19	14.7	100	71	84.3
176	May 3-5	May 18-23	16.4	100	71	84.4
177	May 4-5	May 18-24	15.3	100	71	84.4
178	May 4-5	May 18-27	16.6	100	71	84.7
179	May 5-7	May 19-23	15.3	100	71	84.2
180	May 5-6	May 19-23	14.8	100	71	84.2
181	May 5-7	May 19-23	14.6	100	71	84.2
182	May 7-10	May 20-29	13.1	100	71	84.6
183	May 9-10	May 20-26	14.4	100	71	85.2
184	May 10-15	May 22-27	13.5	100	71	85.6
185	May 11-14	May 20-26	12.6	100	75	86.5
186	May 12-14	May 22-26	12.8	100	75	87.0
187	May 12-15	May 22-27	12.8	100	75	86.8
188	May 14-17	May 24-28	11.2	100	76	87.0
189	May 15-17	May 27-31	13.8	100	76	86.3
190	May 16-17	May 28-31	13	100	76	86.0
191	May 16-17	May 26-30	12.5	100	76	86.9
192	May 16-17	May 26-29	11.3	100	76	86.3
193	May 17-21	May 31-June 3	13.3	98	76	85.5

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature Max.	Min.	Mean
	1919	1919				
194	May 19-20	May 31-June 2	13.5	94	76	85.3
195	May 20-21	June 2-6	13.8	96	76	84.5
196	May 19-21	June 1-4	13.3	94	76	84.9
197	May 21-24	June 2-5	12.7	94	76	84.5
198	May 22-23	June 1-8	12.5	100	76	85.0
199	May 22-24	June 2-6	12.1	96	76	84.4
200	May 23-25	June 4-9	13.1	101	76	85.5
201	May 24-25	June 4-7	13.7	96	76	84.3
202	May 24-25	June 8-10	14.3	101	76	85.5
203	May 25-26	June 6-10	13.7	101	76	85.6
204	May 26-27	June 7-10	13.3	101	76	85.7
205	May 27	June 9-10	13.8	101	76	85.8
206	May 27-28	June 10-11	13.5	101	76	85.6
207	May 28	June 10-11	13.7	101	76	85.5
208	May 28-29	June 11-12	13.8	101	76	85.8
209	May 29-31	June 9-12	11.6	101	76	85.8
210	June 1	June 14-15	13.8	101	76	86.8
211	June 3-5	June 13-18	12	101	76	86.8
212	June 3-4	June 13-21	12.7	101	76	87.3
213	June 4-5	June 16-18	12	101	76	87.3
214	June 5	June 14-16	11.4	101	76	88.0
215	June 4-5	June 13-19	12.4	101	76	87.5
216	June 5-6	June 15-25	13.4	101	76	88.1
217	June 7	June 16-22	12	101	76	88.7
218	June 8	June 16-20	11.3	101	76	88.5
219	June 9	June 20-22	11.2	96	76	88.0
220	June 9-10	June 19-22	11.6	96	76	88.0
221	June 10-11	June 21-23	11.8	96	76	87.8
222	June 10-11	June 21-24	12	96	76	87.9
223	June 11	June 22-25	12.1	96	80	88.3
224	June 11-12	June 21-28	12.2	96	80	88.3
225	June 12	June 22-25	11.5	95	80	88.2
226	June 14-15	June 23-28	10.7	94	80	88.0
227	June 15	June 25-30	12.2	95	80	88.4
228	June 16-17	June 25-27	11.6	94	81	88.5
229	June 16-17	June 27-30	10.2	95	81	88.8
230	June 17-18	June 25-30	10.1	95	81	88.9
231	June 18-22	June 26-30	9.5	95	81	88.9
232	June 19-21	June 28-July 1	10.1	96	81	89.1
233	June 20-22	June 28-July 5	10	97	81	90.0
234	June 21-22	June 27-July 3	9.6	96	81	89.9
235	June 22-23	June 30-July 6	10.8	97	83	91.0
236	June 21-24	June 30-July 1	9.4	96	81	89.0
237	June 24	July 1-5	8.2	97	84	91.3
238	June 25-26	July 1-5	7.7	97	84	91.6
239	June 26-27	July 4-6	8.8	97	84	92.1
240	June 27	July 3-7	8.4	97	84	92.5
241	June 28-29	July 3-6	7.7	97	87	93.0
242	June 29-30	July 6-7	8.2	97	88	93.3
243	June 29-30	July 8-9	8.7	97	85	93.1
244	June 29	July 6-12	9.4	100	85	93.6
245	June 30-July 1	July 7-14	8.7	100	85	94.5
246	July 1	July 9-12	9	100	85	93.9
247	July 2	July 10-13	9.3	100	85	94.3
248	July 3	July 12-13	9.5	100	85	94.3
249	July 6-7	July 13-18	9.1	101	85	94.8
250	July 7	July 14-19	8.8	101	85	94.7
251	July 7-8	July 12-15	7.3	100	85	95.0
252	July 9	July 16-19	8.6	101	87	95.2
253	July 9	July 15-19	8	101	87	95.2
254	July 9-10	July 16-19	7.8	101	87	95.2
255	July 10	July 16-19	8.1	101	87	95.4
256	July 10-11	July 18-21	8	101	87	95.2
257	July 11	July 17-21	8.1	101	87	95.2
258	July 11-12	July 17-21	7.6	101	87	95.2
*259	July 12-13	....	....	....	....	....
260	July 13-14	July 19-24	7.6	101	86	93.5
261	July 14-16	July 20-26	9.3	101	86	92.8
262	July 16	July 25-29	10.2	101	85	92.4
263	July 17	July 25-27	9.9	97	86	92.8
264	July 18-19	July 27-28	9.6	97	85	91.9
265	July 19	July 26-Aug. 2	9.7	98	85	92.8
266	July 19	July 28-31	10.2	98	85	92.5
267	July 19-20	July 28-Aug. 2	10.8	98	85	92.8
268	July 21	July 31-Aug. 1	11.4	98	85	92.4
269	July 22	Aug. 1-3	11.2	98	85	92.6
270	July 22-23	Aug. 2-4	11.3	98	85	92.7
271	July 23-24	Aug. 3-5	10.6	98	85	93.2

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature		
				Max.	Min.	Mean
272	July 24-25	Aug. 4-6	10.5	98	85	93.4
273	July 27-28	Aug. 4-6	9	98	85	93.7
274	July 28-29	Aug. 5-6	8.4	98	90	94.1
275	July 30	Aug. 7-10	9	98	90	93.9
276	July 30-Aug. 3	Aug. 7-11	8.5	98	90	94.0
277	Aug. 1	Aug. 11	10	98	90	93.8
*278						
279	Aug. 1	Aug. 9-14	10.4	98	88	93.1
280	Aug. 2-3	Aug. 12-13	11.5	98	88	93.1
*281						
282	Aug. 3-5	Aug. 12-14	9	98	88	93.0
*283	Aug. 6					
284	Aug. 7	Aug. 16	9	98	88	92.5
285	Aug. 8	Aug. 16-17	9.2	98	88	92.3
286	Aug. 8-9	Aug. 17-18	9.6	98	88	92.3
287	Aug. 10	Aug. 18-19	8.8	95	85	92.0
288	Aug. 11	Aug. 18-20	8.9	95	85	91.3
289	Aug. 11	Aug. 19-25	10	95	81	89.5
290	Aug. 12	Aug. 18-27	10.8	95	80	88.9
291	Aug. 12-13	Aug. 23-26	12.3	95	80	89.0
292	Aug. 13-14	Aug. 26-27	13.6	95	80	88.7
293	Aug. 10-14	Aug. 21-28	11.7	95	80	89.2
294	Aug. 14	Aug. 26	12	95	80	88.7
295	Aug. 15-16	Aug. 25-28	11.2	95	80	88.2
296	Aug. 16-17	Aug. 28-29	11.5	95	80	88.0
297	Aug. 18	Aug. 27-29	10.8	95	80	87.2
298	Aug. 19	Aug. 28-29	10.5	93	80	86.9
299	Aug. 19-20	Aug. 26-Sept. 5	11.7	95	77	85.6
300	Aug. 20-21	Aug. 29-Sept. 3	11.8	95	77	87.0
301	Aug. 21	Sept. 4-8	15.4	95	77	86.1
302	Aug. 22	Sept. 3-8	14.5	95	77	86.1
303	Aug. 23	Sept. 4-9	15.2	95	77	86.3
304	Aug. 25	Sept. 8	14	95	77	86.2
305	Aug. 26	Sept. 8-9	13.6	95	77	86.4
306	Aug. 26-27	Sept. 8-9	13.3	95	77	86.4
307	Aug. 27-28	Sept. 6-10	12.3	95	77	86.7
308	Aug. 28-29	Sept. 10-12	13	96	77	87.2
309	Aug. 29-30	Sept. 11	13	95	77	86.7
310	Aug. 31	Sept. 12-13	12.5	97	77	86.5
311	Sept. 2-3	Sept. 13-16	12.3	97	77	86.0
312	Sept. 2	Sept. 14-15	12.5	97	77	86.1
313	Sept. 2-3	Sept. 15-17	13.3	97	77	85.9
314	Sept. 3	Sept. 17-18	14.8	97	77	86.2
315	Sept. 4-6	Sept. 18-19	15.2	97	77	86.5
316	Sept. 5	Sept. 22-25	17.9	97	74	85.6
317	Sept. 6	Sept. 23-29	20.7	97	74	85.1
318	Sept. 8-9	Sept. 23-25	16.4	97	74	86.0
319	Sept. 11-12	Sept. 24-27	12.8	97	74	84.4
320	Sept. 13-15	Sept. 25-28	12.3	92	74	83.7
321	Sept. 16	Sept. 29	13	96	74	82.1
322	Sept. 16-18	Sept. 28-29	12.2	96	74	82.1
323	Sept. 17	Sept. 29-Oct. 1	13.3	96	74	84.1
324	Sept. 18	Oct. 1-3	14.3	96	74	84.3
325	Sept. 19	Oct. 1-3	13	96	74	84.1
326	Sept. 20	Oct. 4-8	15.6	96	74	84.4
*327	Sept. 20-21					
328	Sept. 21-22	Oct. 3-7	13.7	96	74	84.1
329	Sept. 22	Oct. 4-7	13.5	96	74	83.8
330	Sept. 22-23	Oct. 8-11	17	96	74	84.3
331	Sept. 23	Oct. 9-13	18	96	74	83.7
332	Sept. 24	Oct. 12-13	18.6	96	74	84.1
333	Sept. 24-28	Oct. 10-18	18.5	96	69	82.3
334	Sept. 26-27	Oct. 11-18	17.5	96	69	82.7
335	Sept. 27-28	Oct. 12-19	16.6	96	69	82.4
336	Sept. 30	Oct. 13-18	15	94	69	82.2
337	Oct. 3-4	Oct. 18-20	15.5	93	69	80.3
338	Sept. 30-Oct. 6	Oct. 17-28	13	94	69	82.3
339	Oct. 6-10	Oct. 22-25	15.7	91	69	80.2
340	Oct. 8-10	Oct. 23-27	15.6	91	69	80.4
*341						
*342						
343	Oct. 8	Oct. 23-27	15.8	91	69	80.4
344	Oct. 10-14	Oct. 25-28	15.6	90	69	79.9
345	Oct. 8-15	Oct. 25-28	15.1	91	69	80.7
346	Oct. 15-16	Oct. 28-Nov. 3	15.1	90	69	79.9
347	Oct. 17	Oct. 27-28	13.5	90	69	81.4
348	Oct. 18	Oct. 28-31	12	90	70	81.6
349	Oct. 17-20	Oct. 28-Nov. 7	11.5	90	69	83.5

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature		
				Max.	Min.	Mean
	1919	1919				
350	Oct. 22-23	Oct. 29-Nov. 6	10	90	72	81.0
351	Oct. 21-24	Nov. 1-9	12.6	94	72	81.3
352	Oct. 23-25	Oct. 31-Nov. 8	12.1	90	72	80.7
353	Oct. 24-25	Nov. 3-6	13.2	90	72	80.2
354	Oct. 25	Nov. 6-9	14	94	72	80.2
355	Oct. 26	Nov. 3-10	13.7	94	72	80.2
356	Oct. 26-28	Nov. 6-14	15.3	94	66	79.6
357	Oct. 27-30	Nov. 9-17	16.7	94	66	79.1
358	Oct. 29-31	Nov. 9-16	14.1	94	66	79.4
359	Oct. 30-31	Nov. 15-16	15.7	94	66	79.0
360	Oct. 31-Nov. 3	Nov. 14-16	14	94	66	79.0
361	Oct. 31-Nov. 1	Nov. 16-21	14.5	94	66	78.9
362	Nov. 1-3	Nov. 17-23	14.8	94	66	79.1
363	Nov. 5-8	Nov. 15-26	13.4	94	66	80.7
364	Nov. 7-8	Nov. 20-23	13.7	94	66	80.0
365	Nov. 9-10	Nov. 22-29	13.5	94	66	79.5
366	Nov. 10-11	Nov. 20-28	14.2	89	66	79.9
367	Nov. 11	Nov. 20-30	13.7	89	66	78.7
368	Nov. 12	Nov. 24-27	13.8	89	66	79.9
369	Nov. 13-14	Nov. 25-Dec. 3	14.4	89	64	77.4
370	Nov. 13-15	Nov. 27-Dec. 1	14.9	89	64	78.2
371	Nov. 14-15	Nov. 28-Dec. 3	15.3	89	64	77.6
372	Nov. 16	Nov. 26-Dec. 5	14.5	89	64	77.1
373	Nov. 17	Nov. 28-Dec. 9	16	94	64	78.1
374	Nov. 18	Dec. 1-8	16.5	94	64	77.8
375	Nov. 18	Dec. 3-8	19.2	94	64	77.8
376	Nov. 18-19	Dec. 5-9	17.8	94	64	78.1
377	Nov. 19	Dec. 1-8	16.6	94	64	77.7
378	Nov. 20	Dec. 5-11	18.1	94	64	77.6
379	Nov. 20-21	Dec. 8-11	19	94	64	77.6
380	Nov. 21	Dec. 8-13	18.2	94	60	77.3
381	Nov. 21-22	Dec. 9-14	19.5	94	60	77.0
382	Nov. 24	Dec. 12-16	19.5	94	60	75.3
*383	....	....	....	....	....	....
384	Nov. 25	Dec. 11-15	18.7	94	60	75.1
385	Nov. 26-Dec. 3	Dec. 14-27	22.8	94	56	75.5
386	Nov. 28-30	Dec. 13-26	22.8	94	56	76.0
387	Dec. 1-4	Dec. 20-27	19.5	94	56	76.4
388	Dec. 4	Dec. 22-31	19.7	94	56	77.8
389	Dec. 5	Dec. 20-30	20.7	94	56	77.8
390	Dec. 6	Dec. 23-Jan. 4, 1920	22.4	94	56	78.1
391	Dec. 6	Dec. 26-Jan. 4, 1920	24.1	94	56	78.1
392	Dec. 8	Dec. 31-Jan. 4, 1920	25.6	93	56	77.6
		1920				
393	Dec. 8	Jan. 1-7	26.8	93	56	77.3
394	Dec. 9	Dec. 30-Jan. 12	26.6	93	56	77.2
395	Dec. 10	Jan. 1-8	26.4	93	56	77.2
396	Dec. 11	Jan. 4-7	26.6	93	56	77.3
397	Dec. 12	Jan. 7-9	26.3	93	56	77.1
398	Dec. 13	Jan. 6-17	27.8	96	56	78.4
399	Dec. 18	Jan. 6-14	23	93	56	81.7
400	Dec. 19	Jan. 7-15	24	93	56	81.3
401	Dec. 20	Jan. 13-17	25.2	96	56	81.5
402	Dec. 22	Jan. 14-17	24.7	96	56	82.1
403	Dec. 23	Jan. 15-22	26	96	56	79.7
*404	Dec. 24	....	....	....	....	....
405	Dec. 24-25	Jan. 14-25	25.3	96	56	79.4
406	Dec. 25	Jan. 14-23	22.5	96	56	79.8
407	Dec. 26-27	Jan. 17-19	22	96	71	80.3
408	Dec. 27	Jan. 17	21	96	71	80.0
409	Dec. 29	Jan. 18-19	20.7	96	71	80.5
410	Dec. 30	Jan. 17-23	21.1	96	70	80.5
411	Dec. 31	Jan. 19-23	21.5	96	70	80.8
	1920					
412	Jan. 1	Jan. 20-26	22.7	96	70	83.0
413	Jan. 2	Jan. 21-26	22.2	96	70	83.2
414	Jan. 3	Jan. 22-26	21.7	96	80	83.5
415	Jan. 4	Jan. 23-27	21.3	96	70	83.5
416	Jan. 4-5	Jan. 23-28	20.4	96	70	83.2
417	Jan. 5-6	Jan. 23-31	19.6	96	64	79.3
418	Jan. 6	Jan. 23-Feb. 1	18.8	96	64	79.9
419	Jan. 7	Jan. 23-Feb. 7	22.2	96	64	80.3
420	Jan. 7-8	Jan. 23-Feb. 1	18	96	64	80.0
421	Jan. 8	Jan. 27-Feb. 3	22.3	96	64	80.3
422	Jan. 9-10	Jan. 24-Feb. 5	21	96	64	80.6
423	Jan. 10-11	Jan. 24-31	19.7	96	64	80.3
424	Jan. 11-12	Jan. 24-30	18	96	64	80.3
425	Jan. 13	Jan. 27-Feb. 4	18.8	96	64	80.9

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature Max.	Temperature Min.	Temperature Mean
	1920	1920				
426	Jan. 14-15	Jan. 30-Feb. 5	17.4	96	64	80.8
427	Jan. 16	Feb. 2-6	19.5	96	64	80.4
428	Jan. 17	Feb. 6-7	20.5	95	64	80.2
429	Jan. 18-19	Feb. 5-9	18.8	95	64	79.5
430	Jan. 20	Feb. 2-7	16	95	64	79.1
431	Jan. 21	Feb. 4-6	14.7	95	64	78.5
432	Jan. 22-23	Feb. 4-7	15.2	95	64	78.8
433	Jan. 24	Feb. 7	14	95	64	79.0
434	Jan. 26	Feb. 9-11	14.6	95	64	78.9
435	Jan. 27	Feb. 6-11	13.2	95	64	79.1
436	Jan. 27-28	Feb. 7-11	12.8	95	64	79.1
437	Jan. 28	Feb. 9-11	12.5	95	64	79.3
438	Jan. 29	Feb. 9-13	12	95	64	79.1
439	Jan. 30	Feb. 11-15	12.5	95	66	78.8
440	Jan. 30	Feb. 12-22	17.8	95	58	77.5
441	Feb. 2	Feb. 11-25	17.7	95	58	77.0
442	Feb. 3	Feb. 17-27	18.8	90	58	76.2
443	Feb. 5	Feb. 21-26	18.5	90	58	76.1
444	Feb. 6	Feb. 22-25	17.1	88	58	75.9
445	Feb. 7	Feb. 22-24	15.8	88	58	75.4
446	Feb. 9	Feb. 24-27	16.1	88	58	78.8
447	Feb. 10	Feb. 25-March 1	18.3	88	58	74.1
448	Feb. 10-11	March 1-2	18.6	88	58	73.7
449	Feb. 10	March 1-4	20.3	88	58	73.6
*450	....	....	....	....	....	....
451	Feb. 12	Feb. 24-March 11	21.7	90	55	72.4
452	Feb. 12-18	March 5-11	21	90	55	72.4
453	Feb. 18	March 6-14	20.8	92	55	74.1
454	Feb. 19-20	March 12-14	22.8	92	55	73.9
455	Feb. 21	March 14-15	21.3	92	55	73.3
456	Feb. 22	March 15-18	22.6	92	55	74.6
457	Feb. 22-23	March 13-19	21.5	92	55	75.0
458	Feb. 23	March 15-19	22.8	92	55	74.8
459	Feb. 26	March 18-26	22.4	92	55	76.1
460	Feb. 26	March 19-26	23.1	92	55	76.1
461	Feb. 27	March 21-26	24.8	92	55	76.3
462	Feb. 28	March 21-28	25.2	92	55	76.8
463	March 1	March 25-27	25.8	92	55	77.4
464	March 2	March 27-30	25.3	92	55	77.8
465	March 4	March 29-April 1	26.5	92	55	78.2
466	March 6	March 31-April 3	26.8	92	55	79.0
467	March 7	March 31-April 3	25.9	92	55	79.6
468	March 8	March 31-April 2	25.1	92	62	80.6
469	March 10	April 1-4	24.3	92	73	80.6
470	March 12	April 3-5	23.1	92	68	79.9
471	March 13	April 5-7	23.7	92	68	79.4
472	March 14	April 7-9	25	87	68	79.3
473	March 14-15	April 5-11	24.8	87	68	79.5
474	March 15	April 5-12	25	87	68	79.6
475	March 14-18	April 7-14	23.7	87	68	79.4
476	March 18-19	April 9-15	24.4	87	68	79.1
477	March 20	April 13-14	24.2	87	68	78.8
478	March 21-22	April 14-17	22.4	94	68	79.2
479	March 22	April 14-17	21.6	94	68	79.3
480	March 23-24	April 15-18	21.3	94	68	79.6
481	March 25-26	April 17-18	22.1	94	68	79.5
482	March 27-28	April 17-20	21	94	68	79.7
483	March 28	April 18	21	94	68	79.2
484	March 29	April 18-19	19.8	94	68	79.5
485	March 30	April 18-19	19.2	94	68	79.7
486	March 31-April 1	April 18-19	18	94	68	80.1
487	April 1-2	April 20-21	18.3	94	68	80.4
488	April 2	April 19-21	18.5	94	68	80.4
489	April 3	April 20-22	18.6	94	68	80.9
490	April 4	April 20-27	18.5	94	68	81.4
491	April 5-6	April 20-27	17.4	94	71	81.9
492	April 6-7	April 23-24	17	94	73	82.6
493	April 8	April 25	17	94	73	83.0
494	April 9	April 26	17	94	73	83.1
495	April 10	April 27	17	94	73	82.7
496	April 10	April 25-27	16	94	73	82.7
*497	....	....	....	....	....	....
498	April 9	April 25-26	16.6	94	73	83.1
499	April 10	April 26-27	16.6	94	73	82.7
500	April 11	April 27	16	94	73	82.1
501	April 12	April 29	17	94	73	82.8
502	April 13	April 30	17	94	73	82.3
503	April 13	April 28-May 2	16.3	94	73	82.5

*Incomplete record.

Table 9—Duration of Pupal Stage—Continued

Lot No.	Pupated	Emerged	Average period, days	Temperature		
				Max.	Min.	Mean
	1920	1920				
504	April 14	April 30-May 3	16.7	94	73	83.1
505	April 15	April 30-May 3	16	94	73	83.3
506	April 16	April 29-May 3	14.5	94	73	83.4
507	April 17	May 2	15	90	73	82.7
508	April 18	May 3	15	91	73	82.8
509	April 19	May 3-4	14.5	94	73	82.8
510	April 22	May 6	14	94	73	83.7
511	April 23	May 7	14	94	73	84.0
512	April 23	May 8	15	94	73	84.3
513	April 24	May 7-8	13.7	94	73	84.4
514	April 25	May 8-9	13.7	94	73	84.9
*515	....	....	....	....	....	....
516	April 26-27	May 9-11	13.2	94	73	85.5
517	April 28	May 11-12	13.3	94	76	87.2
518	April 29	May 11	12	94	79	87.8
519	April 30	May 12	12	94	82	88.3
520	May 1	May 12	11	94	84	88.7
521	April 30	May 11	11	94	82	88.3
522	May 1	May 14	13	94	84	87.5
523	April 30-May 1	May 16	16	94	80	87.9
524	May 3-4	May 16-20	14.3	94	75	87.0
525	May 6	May 20	14	93	75	86.4

*Incomplete record.

The existing temperatures during the period of observation were recorded by a thremograph. For each period, are given its maximum temperature and its minimum temperature. The mean temperature given is the average of the daily mean temperatures occurring over the period.

In Table 10 is given the yearly variation in the duration of the pupal stage. The mean temperature does not have a definite effect on its length. The average length of the period, for both the summer and winter months, seems to be influenced more by extreme temperatures.

Table 10 Yearly Variation in Duration of Pupal Stage

Date	Period, days	Temperature, mean
May, 1918	9.6	78.4
May, 1919	13.7	84.7
June, 1918	10.3	94.0
June, 1919	10.6	85.2
December, 1918	....	81.6
December, 1919	23.7	76.9
January, 1919	15.5	79.1
January, 1920	17.8	79.1

A summary containing the longest, the shortest, and the average duration of the pupal stage from May, 1918 to May, 1920, is given in Table 11. The average monthly period was obtained by totalling the daily observations and dividing by the number of collections of pupae observed during the month. During the time in which these observations were made, the longest period and the shortest period averaged 18.6 days and 11.6 days, respectively. The average of the pupal stage over the entire period of observation was 15.2 days. The mean temperature during this time was 83.2 degrees F.

Table 11 Summary of Duration of Pupal Stage

Month	Temperature, mean	Longest period	Shortest period	Average period	Collections of pupae observed
1918					
May	78.4	11.3	7	9.6	19
June	94.0	13.3	7.6	10.3	30
July	97.2	16.1	8	11.2	18
1919					
January	79.1	17.3	10.5	15.5	13
February	78.8	17.5	12.8	15.8	27
March	80.4	21.1	15	18.6	29
April	82.4	19.2	13	15.8	30
May	84.7	16.6	11.2	13.7	39
June	85.2	13.8	7.7	10.6	36
July	92.3	11.4	7.3	9.2	30
August	90.8	15.4	8.8	11.6	31
September	85.1	20.9	12.2	15.1	25
October	84.5	16.7	10	14.1	23
November	79.0	22.8	13.4	16.7	24
December	76.9	27.8	19.5	23.7	24
1920					
January	79.1	22.7	12	17.8	29
February	76.6	25.2	15.8	20.5	21
March	77.0	26.8	18	23.3	24
April	80.7	18.6	11	15.4	35

Transformation to Adult

Shortly before transformation to the adult, the abdomen of the pupa becomes distended and smoother, and is more pointed on the posterior end. The elytra are now darker in color, and the proboscis is more rigid and elongated, and is pushed away from the ventral side of the thorax. Transformation begins by a series of abdominal contractions and twisting movements, which first break the pupal skin on the dorsum of the thorax just between the base of the wings. From this point the skin splits forward over the dorsum of the prothorax and is pulled ventrally over the head and proboscis by vigorous contractions. The antennae are pulled posteriorly during this operation and are finally detached from the old skin by means of the legs. At the same time the skin is split backward on the dorsum of the abdomen from the point of the initial break, and is gradually pushed posteriorly by abdominal contractions, releasing the legs, which soon become rigid enough to assist materially in the completion of casting the pupal skin. Normally the latter does not remain attached to the tip of the abdomen, but is soon pushed off completely by the legs. The wings are exposed from beneath the elytra, and are at first wrinkled or folded. However, they soon expand and extend their full length beyond the tip of the wing covers and abdomen. They are retained in this position until sufficiently hardened, when they are folded in their normal manner and drawn under the elytra. In Figure 3 are shown newly transformed adults with the wings fully distended. The time consumed in transformation to adult averaged a little more than one hour.

Adult

Before Emergence.—Immediately after its transformation from the pupa the adult weevil is white, with black eyes, mandibles, and claws. The darker colorings soon begin to appear. They first become apparent on the legs, then on the elytra, head, and beak. The change takes place slowly and sometimes several days elapse from the beginning of the stage until the weevil has assumed its natural coloration and hardness. Before emergence the weevil is soft-bodied and comparatively helpless, being incapable of definite locomotion. If removed from the pupal cell, it totters on its legs and invariably falls upon its side or back, unable to regain an upright position. The time from transformation of the pupa to the adult, until the weevil is able to travel, is spent in the pupal cell or larval burrow.

Emergence.—The usual method of emergence from the tuber is accomplished by the weevil's cutting a hole of sufficient size, with its mandibles, to permit its body to pass through. The emergence holes are irregular in shape and frequently several weevils leave the tuber through the same exit. This is especially true if tubers are heavily infested. At the time that the weevil leaves the tuber, it usually has assumed its natural color, but its body is still soft and does not attain its normal degree of hardness until some time after feeding has begun.

Description.—The adult sweet potato weevil is a snout-beetle with a narrow head and thorax, long legs, and a distended body, giving it an ant-like appearance, from which it very likely received its specific name, *formicarius*. The snout or beak slightly curved, stout, black, and about twice as long as the head. The antennae attached to the snout at about the middle or slightly beyond, reddish-brown in color, and the distal segment thickly covered with short bristly hairs; in the male this segment longer, and in the female shorter, than all the other segments combined. Eyes black, convex, smooth and shining. Head black, fitting in the front end of the prothorax and movable like a ball and socket joint. Prothorax in front slightly wider than the head, greatly constricted behind, reddish-brown in color. The elytra wider than the head or thorax, elongate-oval in shape, very convex on the dorsum, metallic or dark-blue in color, and folded tightly upon the body hiding completely the wings beneath them. The wings white, nearly twice as long as the elytra; the basal portion has several prominent dark-colored veins extending nearly to the middle. The venation on distal part of the wing much less definite and conspicuous. When in natural position the wing near the middle folded beneath the basal half, and again near the tip, with the latter fold directed posteriorly. The legs reddish-brown with darker markings on distal portion of the femora and tarsal joints. The claws black. The length of the weevil, including the snout extended, ranges from 5.5 mm. to 8 mm., or about one-fourth of an inch. Views of the adult are shown in Figure 3.

Summary of Development

All the stages of the sweet potato weevil are subject to great variation, even under similar conditions, as will be noted in the foregoing tables. In Table 12 are given the shortest and longest periods noted for the egg, larval, and pupal stages. All the shortest periods combined comprised but 21.8 days, and the sum of the longest periods was 77.7 days. The total number of days that comprised the shortest periods is not sufficient for the development of a single generation,

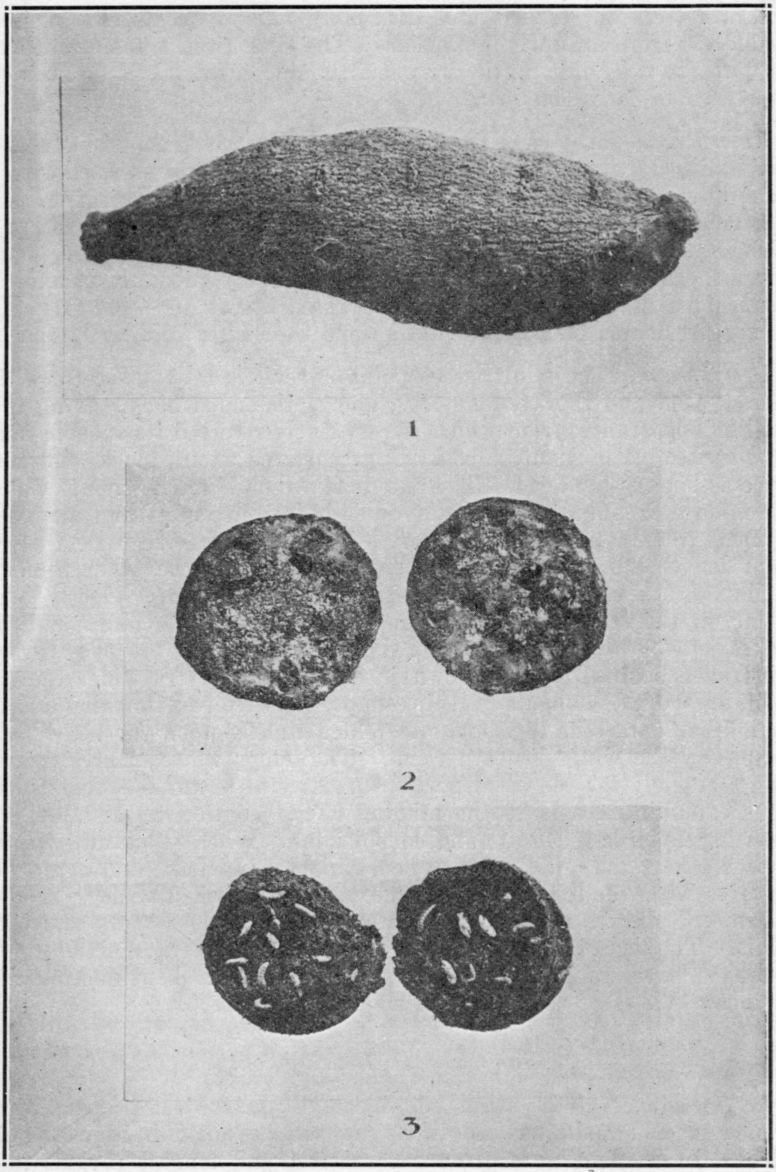

Figure 4. Sweet potatoes showing injury by the sweet potato weevil: 1, tuber showing feeding punctures; 2, cross section of tuber showing larval tunnels; 3, infested tuber showing larvae and pupae in the burrows.

while almost three generations were obtained during the total time consumed by the longest periods.

Table 12 Summary of Development of Sweet Potato Weevil

	Egg days	Larva days	Pupa days	Total days
Shortest	4.8	10	7	21.8
Longest	14.3	35.6	27.8	77.7

Feeding Habits

A short time after emergence the weevil begins to feed. It prefers to feed on the tuber, but when the latter is not accessible it will feed on the foliage and vines without any apparent inconvenience. The adult insect is secretive and avoids exposure by feeding on the under side of the foliage and stems near the ground. This practice of feeding on the plant above ground is most pronounced in the early part of the season. The larvae resulting from eggs deposited in the stems usually tunnel downward beneath the surface and may eventually reach the tubers. It is doubtful, however, if most of the tubers in the field become infested in this manner. Field observations indicate that the tubers more commonly become infested by adult weevils reaching those that are exposed by cracks in the soil, cultivation, or shallow planting. The weevil may burrow through loose soil for a short distance in order to reach the tuber. An infested vine become light green in color and assumes a "sickly" appearance, and in case of a severe infestation it dies. As a general rule, however, weevils attacking the plants above ground are not sufficiently abundant to cause a widespread destruction of the vines. Usually a careful search is necessary to locate an infestation and for this reason the presence of the weevil is not suspected frequently until the tubers have become badly infested.

The insect in both the larva and adult stages feeds on the tubers in the field and in storage. Adults may feed in groups, although single individuals were frequently observed attacking vines and tubers. The latter are attacked usually on the under side, and at the tip or other irregular places on the surface. The feeding cavity resembles a minute pin puncture and is directed invariably straight into the tuber. Newly hatched larvae usually begin tunneling towards the center of the tuber, but follow no definite course, and the tunnel of a single larva may intersect itself several times. The larva always avoids eating through to the surface and exposing the burrow. As it continues to feed, the tunnel behind it is filled with excreted and waste material. When a tuber contains a large number of larvae the interior portion may be riddled completely, while from the outside it appears to be perfectly sound. Sometimes such infested tubers are placed in storage, where the adults emerge and continue to feed and propagate in the stored tubers. There is no discernible difference in the method of feeding of the two sexes.

Location of Food

Normally the adult weevil is never found far removed from its source of food supply. The ability to locate food through its own efforts is very limited, because of its restricted means of locomotion. Notwithstanding this, isolated plants and fields of sweet potatoes are found frequently to be infested with weevils. The most plausible explanation to be offered in this connection is that the weevil is assisted to its food supply through the use of infested slips or draws. According to all the available information, this is considered the most important means by which the insect gains access to its source of food. Flight is possible, but there are no data available at this time which indicate that this method of travel in the search of food is commonly resorted to.

Food within a comparatively short distance is located readily by the weevil. Tubers or remnants left in the field after the crop has been harvested, and volunteer plants, are invariably found with active weevils on them. Several instances were noted where isolated plants of *Ipomoea* (morning-glory) were infested by the weevil. In the laboratory, any tubers left accessible to the weevils were attacked without much delay. There is no apparent difference in the ability of the sexes to locate food.

Table 13 Length of Life of Adults Without Food.

	Male				Female		
No.	Emerged	Died	Period, days	No.	Emerged	Died	Period, days
	1918	1918			1918	1918	
1	Nov. 5	Nov. 13	8	1	Nov. 1	Nov. 9	8
2	Nov. 5	Nov. 14	9	2	Nov. 1	Nov. 9	8
3	Nov. 5	Nov. 14	9	3	Nov. 1	Nov. 12	11
4	Nov. 5	Nov. 16	11	4	Nov. 1	Nov. 16	15
5	Nov. 5	Nov. 16	11	5	Nov. 1	Nov. 12	11
6	Nov. 4	Nov. 15	11	6	Nov. 1	Nov. 12	11
7	Nov. 6	Nov. 16	10	7	Nov. 7	Nov. 14	7
8	Nov. 6	Nov. 13	7	8	Nov. 8	Nov. 17	9
9	Nov. 6	Nov. 16	10	9	Nov. 8	Nov. 13	5
10	Nov. 8	Nov. 14	6	10	Nov. 8	Nov. 16	8
11	Nov. 8	Nov. 16	8	11	Nov. 8	Nov. 18	10
12	Nov. 8	Nov. 14	6	12	Nov. 8	Nov. 18	10
13	Nov. 8	Nov. 17	9	13	Nov. 8	Nov. 22	14
14	Nov. 8	Nov. 17	9	14	Nov. 8	Nov. 19	11
15	Nov. 8	Nov. 14	6	15	Nov. 8	Nov. 24	16
16	Nov. 8	Nov. 17	9	16	Nov. 16	Nov. 28	12
17	Nov. 16	Nov. 22	6	17	Nov. 16	Nov. 28	12
18	Nov. 16	Nov. 26	10	18	Nov. 16	Dec. 3	17
19	Nov. 16	Nov. 24	8	19	Nov. 16	Dec. 3	17
20	Nov. 16	Nov. 26	10	20	Nov. 16	Dec. 3	17
21	Nov. 16	Nov. 26	10	21	Nov. 16	Nov. 30	14
22	Nov. 16	Nov. 28	12	22	Nov. 16	Nov. 28	12
23	Nov. 16	Nov. 26	10	23	Nov. 16	Nov. 28	12
24	Nov. 16	Nov. 28	12	24	Nov. 16	Nov. 30	14
25	Nov. 16	Nov. 28	12	25	Nov. 16	Nov. 28	12
26	Nov. 16	Nov. 30	14	26	Nov. 16	Nov. 22	6
27	Nov. 16	Nov. 28	12	27	Nov. 16	Nov. 24	8
28	Nov. 16	Nov. 24	8	28	Nov. 16	Nov. 22	6
29	Nov. 16	Nov. 28	12	29	Nov. 16	Dec. 3	17
30	Nov. 16	Nov. 28	12	30	Nov. 16	Nov. 28	12
31	Nov. 16	Nov. 28	12	31	Nov. 16	Dec. 1	15
32	Nov. 16	Nov. 26	10	32	Nov. 16	Nov. 28	12
33	Nov. 16	Nov. 26	10	33	Nov. 16	Nov. 30	14
34	Nov. 16	Nov. 26	10	34	Nov. 16	Nov. 30	14
35	Nov. 16	Nov. 28	12	35	Nov. 16	Nov. 30	14
36	Nov. 16	Nov. 26	10	36	Nov. 16	Nov. 28	12
37	Nov. 16	Nov. 24	8	37	Nov. 16	Nov. 28	12
38	Nov. 16	Nov. 26	10	38	Nov. 16	Nov. 30	14
39	Nov. 16	Nov. 26	10	39	Nov. 16	Nov. 26	10
40	Nov. 16	Nov. 24	8	40	Nov. 16	Nov. 30	14
41	Nov. 16	Nov. 28	12	41	Nov. 16	Nov. 28	12
42	Nov. 16	Nov. 26	10	42	Nov. 16	Nov. 28	12
43	Nov. 16	Nov. 26	10	43	Nov. 16	Nov. 30	14
44	Nov. 16	Nov. 26	10	44	Nov. 16	Nov. 26	10
45	Nov. 17	Nov. 28	11	45	Nov. 16	Nov. 28	12
46	Nov. 17	Nov. 26	9	46	Nov. 16	Nov. 28	12
47	Nov. 17	Nov. 26	9	47	Nov. 16	Nov. 26	10
48	Nov. 17	Nov. 30	13	48	Nov. 16	Nov. 26	10

Table 13 Length of Life of Adults Without Food—Continued

Male				Female			
No.	Emerged	Died	Period, days	No.	Emerged	Died	Period, days
	1918	1918			1918	1918	
49	Nov. 17......	Nov. 28.......	11	49	Nov. 16.......	Nov. 30.......	14
50	Nov. 17......	Nov. 28.......	11	50	Nov. 16.......	Nov. 30.......	14
51	Nov. 17......	Nov. 28.......	11	51	Nov. 16.......	Nov. 28.......	12
52	Nov. 17......	Nov. 30.......	13	52	Nov. 16.......	Nov. 28.......	12
53	Nov. 17......	Nov. 28.......	11	53	Nov. 16.......	Nov. 30.......	14
54	Nov. 17......	Nov. 28.......	11	54	Nov. 16.......	Nov. 30.......	14
55	Nov. 17......	Nov. 26.......	9	55	Nov. 16.......	Nov. 28.......	12
56	Nov. 17......	Nov. 26.......	9	56	Nov. 16.......	Nov. 28.......	12
57	Nov. 17......	Nov. 28.......	11	57	Nov. 16.......	Dec. 1........	15
58	Nov. 17......	Nov. 28.......	11	58	Nov. 16.......	Nov. 28.......	12
....	....	....	....	59	Nov. 16.......	Dec. 1.......	15

Length of Life of Adults Without Food

During November, 1918, observations were made on 117 weevils to determine the length of life from emergence, without food, under laboratory conditions. The results obtained from this experiment are given in Table 13. For the male sex, the minimum life period and the maximum life period without food were 6 and 14 days, respectively. The average life of the 58 individuals under observation was 9.9 days. The minimum period for the female sex was 6 days, the same as obtained for the male. The maximum life period and the average life period, however, were longer. Four females lived for 17 days. The average life for the 59 female weevils was 12 days.

From May 29, 1922, to June 11, 1922, 97 weevils of both sexes were isolated without food from the date of emergence. The average time that these weevils lived was about 8.1 days. The mean temperature for the period was 81.5 degrees F.

Average Eggs Per Female

The average number of eggs per female, by the month, for 1919, is given in Table 14. The maximum number, 71, was produced in June, with a mean temperature of 85.2 degrees F. A minimum average number of 47 eggs was noted in November, with a mean temperature of 79 degrees F. The average number of eggs per month for each female during the entire year was 56, in an average mean monthly temperature of 83.2 degrees F.

Table 14 Average Eggs per Female

Date	Temperature, mean	Average No. eggs per female	Total No. of eggs	No. of females ovipositing
1919				
January..........	79.1	57	909	16
February..........	78.8	48	817	17
March..........	80.4	52	722	14
April..........	82.4	52	574	11
May..........	84.7	67	672	10
June..........	85.2	71	571	8
July..........	92.3	58	407	7
August..........	90.8	50	302	6
September..........	85.1	67	600	9
October..........	84.5	61	861	14
November..........	79.0	47	282	6
December..........	76.9	52	628	12

Thus under laboratory conditions each female produced an average of nearly two eggs per day for the entire year. Fortunately, under natural conditions the average number per female is considerably smaller, because low temperatures have a positive effect in diminishing the rate of oviposition.

Proportion of Sexes

From November 3, 1918, to January 25, 1919, 1473 weevils were reared in the laboratory from tubers infested under natural conditions. About 49.5 per cent. of the total number, or 727, were males; slightly over 50 per cent., or 746, were females. Collections made during the active season in the field resulted in taking approximately an equal number of each sex. Table 15 shows the proportion of males and females as they emerged daily in the laboratory.

Table 15 Proportion of Sexes

Date	No. of weevils emerged	Males	Females
1918			
November 3	7	3	4
November 4	13	7	6
November 5	14	9	5
November 6	22	9	13
November 7	27	9	18
November 8	25	12	13
November 11	80	35	45
November 13	125	60	65
November 14	50	21	29
November 15	61	31	30
November 16	42	24	18
November 17	83	32	51
November 18	60	34	26
November 19	91	45	46
November 20-21	248	119	129
November 22	69	29	40
November 23	58	36	22
November 24-25	115	59	56
November 26	82	39	43
November 27	53	29	24
November 28-29	54	33	21
November 30	38	19	19
1919			
January 22	25	17	8
January 25	31	16	15

Protection

All of the immature stages of the sweet potato weevil are afforded an excellent protection by the habits of the insect. The egg is deposited in an especially prepared cavity, the entrance to which is sealed, securing it effectively from injury by sudden changes in temperature or attacks of enemies. Normally the entire larval and pupal stages are spent within the food plant, and they are protected likewise from the attack of parasites and adverse climatic conditions.

Undoubtedly the red and metallic blue coloration of the adult weevil protects it from many enemies. The general texture of the weevil is hard and this probably results in making it an undesirable source of food supply for predacious enemies. Adults avoid danger most commonly by feigning death. Upon disturbance they drop to the ground and remain motionless, frequently feigning death for several minutes.

So long as they remain motionless they are very difficult to see, especially on loose, dark-colored soils. Adults are further protected by their general secretive habits and coloration, which blends effectively with the vines and foliage. While feeding in the field they are rarely observed on the plants unless very close examination is made.

Adaptive Capacity

The sweet potato weevil is restricted to the sweet potato and several closely related plants for its food supply. Some of the wild species of plants of the *Convolvulus* family probably comprised its natural food plants, but at the present time the sweet potato is preeminently the most important source of food. From the time that the insect was first described, nearly two-thirds of a century elapsed before it was reported as attacking sweet potatoes. Generally the latter is considered to be an acquired food plant.

All varieties of sweet potatoes are subject to attack, and when tubers are not accessible in the field, the insect feeds and propagates on the vines, without apparent inconvenience.

According to some experiments conducted by Conradi, the weevil can be forced to accept, for food, plants other than those on which it normally feeds. There is no available record, however, of the weevil's completing its life cycle on any food plant other than the sweet potato or some allied species.

The weevil has a pair of fully developed wings, and is capable of at least limited flights. Up to this time, however, observations seem to indicate that this means of travel is not resorted to, even under the most adverse conditions.

Flight

The weevil has fully developed wings, and several instances of flights have been recorded heretofore. During the time of these observations a number of cases of the weevil in short flights have been noted. Three of the flights which were first observed occurred in the laboratory during February, 1920. These weevils had been confined in tin boxes, and when the latter were opened the weevils, after spreading their wings several times, began flight of their own accord. The greatest distance covered in any case was not over fifty feet. Although the wings are moved very rapidly while in the air, the speed attained by the weevil is only moderate, and its course of flight can be readily followed.

Many attempts to induce flight were made with a large number of weevils, and the results obtained from these experiments prove that the weevil has the ability to make at least limited intermittent flights, either in the open or in the confinement of the laboratory.

The details of several observations on this important subject are given herewith. On May 30, 1922, a male weevil with its wings protruding from beneath the elytra was tossed into the air, and it began to fly upward, taking a spiral course until it reached the ceiling, where it continued to fly in circles, until it became entangled in a spider-web. Up to the time of its interruption the flight was continuous for slightly more than one minute. The weevil was released and again tossed into the air, and after several attempts it began another flight which was directed across the room in a more or less straight course until it struck the opposite wall and fell to the floor. The distance covered during this flight was approximately twenty feet.

On the same day another male weevil was observed to begin flight on being tossed into the air. It began to fly spirally upward, then suddenly downward, when it again resumed its former course. The interesting feature of this observation is the duration of flight. In confinement of the laboratory this weevil remained flying in the air for a period of two and one-half minutes. Many other flights of less duration, that were made by different individuals, have been observed. Male weevils were much more easily induced to fly by being tossed in the air than the females. On May 31, 1922, 15 male specimens were released in the open. There was a brisk south wind. The flight of the first weevil was directed gradually upward in the windward direction and its course was followed for more than 60 yards before it disappeared. This was the longest continuous flight noted in these observations. More commonly the weevils flew spirally upward, and attained a height of 30 feet or more before they were lost from view. Several of the flights were short, being directed obliquely towards the ground.

No weevils were observed in flight, at any time, during the active season in the field. These results indicate, however, that flight is a possible means of dissemination.

Feigning Death

When the weevil is suddenly disturbed or becomes frightened, it feigns death. This habit is the most important means it has for escaping danger. In feigning death the weevil falls upon its side or back, with the legs left either widely spread or slightly drawn together under the body, and the antennae retracted along the ventral side of the beak and head. In this position the weevil may remain motionless for a period of four or five minutes, but if further disturbed, it quickly recovers its footing and attempts to escape by running for any available protection. In cases of undue fear the weevil will oftentimes apparently "forget" to feign death, and will depend wholly upon its running ability to elude its enemies.

The death-feigning habit makes it very difficult to observe the weevil in the sweet potato draw-bed, or among the vines and tops of growing plants in the field.

Reproduction

Sexual Attraction and Copulation.—To ascertain the extent of sexual attraction, several virgin females were placed in small wire cages, and active males were released near these cages at distances varying from a few inches to several feet. In no case was there an immediate definite attraction for the male weevils to the cages. At the conclusion of a 3-hour period the attraction was no more pronounced, and male insects seemed more intent upon secreting themselves than searching for females. The females were then placed in four-ounce tin salve boxes together with the males and copulation was noted several hours thereafter. The general conclusion is that sexual attraction is not very highly developed in this insect, and sexes are attracted only when they actually meet or come into contact with each other, which often occurs because of the insect's sedentary habits.

Several copulations usually occur at irregular intervals during the life of the females. The exact duration of the act was not determined, but several pairs of weevils were noted in copula for a period of at least one hour and ten minutes. During the act of mating the weevils remain quiet and motionless. However, if disturbed, the female immediately begins to crawl, carrying the male with her, or, as is more frequently the case, they separate quickly to avoid danger. There is little question but that both polyandry and polygamy exists among the adults of the sweet potato weevil, since a number of matings frequently occur during the lifetime of the weevil.

Period Between Maturity and Copulation.—Normally transformation to the adult occurs in the larval burrow or pupal cell, within the tuber. Immediately after becoming an adult, the weevil is very soft and helpless, and a period of several days is necessary before it attains a sufficient degree of hardness and strength for emergence. After the weevil emerges, a feeding period is also necessary before it becomes sexually matured.

A number of recently emerged females were confined without food with sexually matured males, for periods ranging from two to five days. They were then placed on fresh tubers, and in each case feeding began immediately, but no oviposition occurred. When the females were allowed to feed for a day or more, and males were then confined with them, oviposition generally began soon thereafter. All the observations made in this connection seem to indicate that mating never takes place prior to feeding. The exact age at which copulation normally takes place has not been determined.

In Table 16 are given the periods from emergence to first oviposition. These results give some idea of the time from maturity to copulation. It should be noted, however, that these periods begin with emergence, and do not include the additional period from the date of transformation to the adult stage to emergence from the tuber.

Fertility.—From all observations made on this point it appears that one successful mating is sufficient to insure the fertility of at least the average number of eggs deposited by the female. Several cases were noted in which all the eggs laid by a female were fertile after one union with a male. Successive matings, however, may take place after the initial fertilization has been effected. Generally, normal oviposition does not occur in the case of unfertilized females, although several instances were observed where such individuals deposited eggs in the usual manner. None of these eggs hatched. More frequently the eggs of unfertilized females are deposited upon the surface of the tuber, but eggs thus exposed soon shrivel and dry, and have never been observed to hatch. Over the entire period of observations, the number of infertile eggs, among those deposited in a normal manner, was very small and did not effect a material reduction in the number of larvae produced.

Oviposition.—With the approach of warm weather in the spring, the weevils become active in the field, and may begin oviposition in the vines before the tubers have begun to develop. The eggs are laid invariably in the lower portions of the vines near or just beneath the surface of the ground. The insect, however, seems to prefer the tuber for oviposition, and the latter is attacked as soon as it has attained a sufficient size.

The act of oviposition is not preceded by any critical examination of the tuber for a favorable locality, or for ascertaining prior infestation. Quite the contrary appears to be true. The eggs are laid promiscuously in all portions of the tuber, some contiguous and others widely scattered. Egg deposition will take place readily in a tuber containing the insect in all of its stages of development, and in cases of severe infestation so many eggs may be deposited in a single tuber that many larvae perish for want of a sufficient food supply.

All normally deposited eggs are placed in especially prepared cavities. *The egg cavity is not as deep as the feeding puncture, but usually is* greater in diameter, and is directed into the tuber at a more oblique angle.

Table 16 Period from Emergence to Oviposition

No.	Female emerged	First egg	Period, days
	1919	1919	
13	January 5	January 13	8
14	January 5	January 13	8
15	January 5	January 13	8
16	January 5	January 12	7
17	January 5	January 17	12
18	January 31	February 9	9
19	April 7	April 8	1
20	April 8	April 16	8
21	May 26	May 28	2
22	May 30	May 31	1
23	July 2	July 5	3
24	July 5	July 8	3
25	June 28	July 1	3
26	August 3	August 8	5
27	August 3	August 19	16
28	August 3	August 19	16
29	August 3	August 25	22
30	July 30	August 1	2
31	July 30	August 1	2
32	August 29	September 24	26
33	August 30	September 24	25
34	September 3	September 10	7
35	September 3	September 23	20
36	September 3	September 10	7
37	September 8	September 10	2
38	October 3	October 4	1
39	October 3	October 4	1
40	October 3	October 4	1
41	October 8	October 9	1
42	October 8	October 10	2
43	October 8	October 9	1
44	November 24	November 27	3
45	November 24	November 27	3
46	November 24	November 27	3
47	November 22	November 27	5
48	November 24	November 27	3
49	November 24	November 27	3
	1920	1920	
50	January 20	January 30	10
51	January 20	February 2	13
52	January 20	January 26	6
53	January 20	January 26	6

When the female has completed the egg cavity she turns about and begins to feel for the entrance of the cavity with the tip of the abdomen by moving it from side to side. Usually the opening is readily located, but sometimes considerable time is spent before she is successful. After the egg cavity has been located with the tip of the abdomen, the ovipositor is protruded into it. At this time the female stands in a humped position, with the legs widespread and the claws firmly imbedded. In this position she may remain motionless for a brief period. Then by a series of abdominal contractions the egg is forced into the cavity, sometimes to the very bottom, but quite frequently only part way. Invariably the upper end of the egg is covered, and the entrance of the cavity is filled, with a quantity of white mucilaginous material, which hardens and becomes darker upon exposure. This seals the egg cavity and at the conclusion of the act of oviposition the female leaves without turning to inspect her work.

The time consumed during the act of oviposition varies considerably with the season and the individual. After the egg cavity has been completed it may require eight minutes to one hour, or more. No extended observations were made during the period of these studies to determine the average time required for oviposition.

In the laboratory, oviposition took place throughout the entire year. Under natural conditions, however, no insects were observed depositing eggs during the winter months at College Station, and the general conclusion is that few eggs are laid during this season, even though weevil activity is manifested on warm days.

Period from Emergence to Oviposition.—The age at which oviposition begins varies greatly with the individual and the season, as will be noted in the accompanying table. Normal oviposition does not take place until fertilization has been accomplished, but generally begins soon thereafter. The age of the female at which oviposition begins is, therefore, dependent upon the time at which successful fertilization is effected.

Observations in this connection, extending from January, 1919, to January, 1920, were made on 41 pairs of weevils. The female in each case, immediately after emergence, was placed on a fresh tuber, together with a male, and the first egg production was noted. The results obtained from these observations are given in Table 16. The length of the period ranged most frequently from 1 to 5 days. The average age of the 41 females at the beginning of oviposition was 6.9 days.

Period of Oviposition.—After an average feeding period of about 7 days, oviposition usually begins, and is continued more or less regularly, depending upon prevailing temperatures, until shortly before the death of the female. In a number of cases the females deposited eggs on the date of their death; however, more frequently a period of one to several days intervenes between last oviposition and death. The periods of oviposition, as they occurred from December 16, 1918, to January 26, 1920, are given in Table 17. It will be noted that the periods vary greatly with the individual and the season. At temperatures which maintain the maximum weevil activity the period of oviposition is generally much shorter. During cold weather egg laying may cease entirely, but is resumed when a rise in temperature occurs. This often results in a great prolongation of the oviposition period. The length of the period ranged from 30 to 209 days. The average period of oviposition of 43 females kept under observation was 104.2 days.

Table 17 Period of Oviposition

No.	First egg	Last egg	Period, days	Temperature, mean
	1918	1919		
1	December 16	April 18	124	80.5
2	December 19	March 30	102	80.2
3	December 16	February 2	49	80.7
4	December 16	June 8	175	81.8
*5	December 16	April 28	134	80.6
*6	December 18	February 11	56	79.5
7	December 18	July 14	209	83.3
8	December 23	March 10	78	80.8
*9	December 19	February 20	64	80.2
10	December 19	April 9	112	80.3
11	December 20	March 14	85	80.6
12	December 20	May 19	151	81.3
	1919			
13	January 13	August 2	202	84.6
14	January 13	April 8	86	79.6
*15	January 13	January 20	8	79.5
16	January 12	April 2	81	79.4
17	January 17	May 22	126	81.8
18	February 9	July 11	153	83.8
19	April 8	July 19	103	86.1
20	April 16	July 9	85	85.8
21	May 28	November 21	178	86.1
22	May 31	August 8	70	90.5
23	July 5	August 10	37	91.5
24	July 8	October 17	102	88.2
*25	July 1	July 3	3	90.5
26	August 8	October 19	73	86.8
*27	August 19	August 19	1	90.0
28	August 19	October 6	49	87.6
29	August 25	March 14, 1920	203	79.5
*30	August 1	August 10, 1919	10	93.9
*31	August 1	August 12, 1919	12	93.6
32	September 24	February 9, 1920	139	80.5
33	September 24	February 11, 1920	141	80.3
*34	September 10	September 15, 1919	6	88.4
*35	September 23	September 30, 1919	8	81.6
36	September 10	January 18, 1920	131	80.9
37	September 10	October 14, 1919	35	84.7
38	October 4	December 6, 1919	64	84.8
*39	October 4	October 23, 1919	20	80.5
40	October 4	November 2, 1919	30	81.2
41	October 9	January 11, 1920	95	79.4
*42	October 10	October 11, 1919	2	85.7
43	October 9	November 12, 1919	35	82.2
		1920		
44	November 27	February 4	70	78.3
45	November 27	March 30	125	76.6
46	November 27	March 22	117	76.4
47	November 27	March 30	125	76.6
48	November 27	February 11	77	77.6
49	November 27	April 26	152	77.3
	1920			
50	January 30	April 26	88	78.1
*51	February 2	February 13	12	79.1
52	January 26	April 14	80	76.9
53	January 26	April 26	92	77.5

*Incomplete record.

Rate of Oviposition.—In Table 18 are given the daily observations made on the rate of oviposition in the laboratory. The rate at which the eggs are deposited often varies considerably from day to day with the same female, under similar conditions. There appears to be no regularity in the number of eggs deposited for a given period. The number of eggs produced during a 24-hour period ranged from 1 to 17. This maximum number was obtained but once during the entire observations, and it occurred on January 19, 1920, at a mean temperature of 89 degrees F. From 3 to 9 eggs were frequently laid during warm weather in a 24-hour period. The period between egg depositions increases as the limit of the average egg quota is approached, and becomes more protracted as the period of oviposition nears completion.

Table 18 Rate of Oviposition

Date	Temperature			Pair Number																
	Max.	Min.	Mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17
1918																				
Dec. 15	87	75	81	M	M	M	M	M	..	..	..	..	..	..	..	..	..	..	..	..
Dec. 16	76	72	74	5	0	7	5	1	..	..	..	..	..	..	..	..	..	..	..	..
Dec. 17	93	77	85	3	0	4	5	5	M	M	M	M	M	M	..	..	..	..	..	..
Dec. 18	93	80	86.5	4	0	4	3	2	2	1	0	0	0	0	..	..	..	..	..	..
Dec. 19	94	75	84.5	3	1	3	4	2	2	2	0	2	2	0	M	..	..	..	..	..
Dec. 20	94	79	86.5	7	1	6	5	5	3	1	0	2	3	3	2	..	..	..	..	..
Dec. 21	93	77	85	1	1	1	1	1	1	2	0	1	0	1	2	..	..	..	..	..
Dec. 22	85	77	81	1	0	1	1	0	1	2	0	0	0	1	1	..	..	..	..	..
Dec. 23	79	77	78	4	0	5	2	3	6	0	1	7	2	4	1	..	..	..	..	..
Dec. 24	83	76	79.5	2	2	0	1	1	1	3	1	1	2	2	2	..	..	..	..	..
Dec. 25	84	80	82	2	2	0	1	0	1	2	0	1	1	2	1	..	..	..	..	..
Dec. 26	85	82	83.5	2	2	2	1	3	2	2	2	2	1	1	2	..	..	..	..	..
Dec. 27	83	73	78	8	3	4	3	7	7	1	1	6	1	2	1	..	..	..	..	..
Dec. 28	84	76	80	3	4	4	2	2	3	2	3	2	4	3	3	..	..	..	..	..
Dec. 29	88	75	81.5	3	4	4	4	1	2	1	3	2	4	2	3	..	..	..	..	..
Dec. 30	93	85	89	3	3	3	4	4	2	4	5	0	3	4	5	..	..	..	..	..
Dec. 31	95	78	86.5	0	4	0	0	0	0	3	4	0	3	2	3	..	..	..	..	..
1919																				
Jan. 1	90	74	82	0	0	0	1	0	1	1	0	0	1	1	2	..	..	..	..	..
Jan. 2	78	65	71.5	2	2	0	2	1	0	0	3	2	2	1	1	..	..	..	..	..
Jan. 3	78	68	73	1	0	0	1	0	2	2	0	2	0	0	1	..	..	..	..	..
Jan. 4	77	72	74.5	1	1	2	2	1	2	1	2	3	2	1	2	..	..	..	..	..
Jan. 5	78	75	76.5	1	0	1	2	1	2	1	1	2	1	1	1	..	..	..	..	..
Jan. 6	80	78	79	3	3	3	2	2	2	2	4	1	1	2	2	M	M	M	M	M
Jan. 7	87	77	82	1	1	1	1	0	1	1	0	0	2	1	1	0	0	0	0	0
Jan. 8	83	67	75	2	1	1	2	1	1	2	1	1	1	0	2	0	0	0	0	0
Jan. 9	80	68	74	2	2	2	2	2	2	1	2	3	3	3	2	0	0	0	0	0
Jan. 10	82	75	78.5	2	1	1	1	2	1	3	2	1	2	1	3	0	0	0	0	0
Jan. 11	85	80	82.5	2	2	2	2	3	1	3	2	2	3	4	4	0	0	0	0	0
Jan. 12	85	81	83	4	2	3	2	1	4	3	3	1	3	1	3	0	0	0	1	0
Jan. 13	87	78	82.5	5	3	2	5	1	4	4	5	1	4	0	4	3	1	1	0	0
Jan. 14	92	77	84.5	2	2	0	1	3	0	1	0	2	0	1	2	1	0	0	2	0
Jan. 15	81	73	77	2	1	3	4	1	3	1	2	1	2	1	2	2	0	0	1	0
Jan. 16	79	73	76	2	1	2	1	0	2	3	2	0	2	0	2	2	4	1	1	0
Jan. 17	80	76	78	4	2	0	0	2	2	1	2	0	1	2	1	1	0	0	2	3
Jan. 18	81	73	77	3	0	3	4	2	4	3	3	2	3	0	1	2	1	1	3	0
Jan. 19	86	72	79	5	1	1	3	4	3	2	4	2	4	1	2	3	2	1	4	3
Jan. 20	88	76	82	4	1	2	0	3	4	3	4	2	3	2	5	1	1	1	3	2
Jan. 21	87	75	81	3	3	5	7	1	3	4	4	4	0	2	4	5	3	0	3	2
Jan. 22	90	73	81.5	5	2	3	5	6	5	3	3	2	3	1	4	5	3	0	3	3

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number																	
	Max.	Min.	Mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1919																					
Jan. 23	93	77	85	5	3	1	4	4	3	3	4	2	3	1	4	2	1	0	4	4	..
Jan. 24	89	72	80.5	3	0	2	3	3	3	2	4	2	4	0	1	1	0	0	1	2	..
Jan. 25	93	63	78	3	3	3	2	3	3	2	2	4	2	2	4	3	1	D	3	0	..
Jan. 26	83	67	75	2	2	2	2	2	2	2	1	3	1	2	4	3	1	..	3	0	..
Jan. 27	78	77	77.5	3	1	0	0	2	2	1	3	2	0	2	2	0	0	..	2	2	..
Jan. 28	82	73	77.5	2	2	3	2	2	2	3	1	3	2	3	3	2	1	..	3	1	..
Jan. 29	88	71	79.5	3	4	2	1	3	3	2	4	2	3	0	3	4	1	..	4	2	..
Jan. 30	90	75	82.5	4	2	4	3	3	4	4	1	2	2	1	4	2	1	..	2	2	..
Jan. 31	93	78	85.5	4	1	2	1	0	4	1	3	2	3	1	4	2	2	..	2	3	..
Feb. 1	87	77	82	2	0	3	2	2	2	2	2	1	2	2	2	2	1	..	3	1	M
Feb. 2	82	77	79.5	2	0	2	2	2	2	2	1	1	2	1	2	1	1	..	3	0	0
Feb. 3	80	75	77.5	0	1	0	2	0	1	1	2	0	0	0	1	1	0	..	1	1	0
Feb. 4	77	65	71	4	0	0	2	1	2	3	1	1	3	2	1	1	3	..	2	1	0
Feb. 5	84	77	80.5	3	2	0	2	0	2	3	2	0	2	0	0	3	0	..	3	3	0
Feb. 6	86	71	78.5	1	1	0	3	1	3	3	2	2	3	3	1	2	2	..	3	2	0
Feb. 7	86	75	80.5	3	1	0	2	1	3	4	4	1	3	0	3	4	1	..	3	4	0
Feb. 8	87	77	82	3	2	0	2	2	3	2	2	1	3	1	2	2	3	..	3	2	0
Feb. 9	83	75	79	2	1	0	1	2	2	1	2	0	2	1	3	2	2	..	2	2	1
Feb. 10	82	73	77.5	3	3	0	3	2	2	2	2	1	2	1	3	3	0	..	3	2	0
Feb. 11	86	65	75.5	3	1	0	2	1	3	3	2	2	1	2	3	2	2	..	3	2	1
Feb. 12	85	70	77.5	4	4	0	1	3	0	3	2	2	3	3	2	4	2	..	3	4	3
Feb. 13	89	78	83.5	5	0	0	3	2	L	3	5	2	3	1	2	2	0	..	3	3	2
Feb. 14	93	83	88	4	2	0	3	1	..	4	2	3	3	3	3	4	1	..	1	2	1
Feb. 15	90	70	80	4	3	0	4	2	..	4	5	2	3	2	4	4	1	..	5	1	3
Feb. 16	93	71	82	4	2	0	3	2	..	3	5	2	2	2	3	3	1	..	4	1	2
Feb. 17	93	75	84	3	3	0	3	2	..	4	2	2	4	1	2	4	1	..	5	0	3
Feb. 18	88	70	79	2	0	0	3	3	..	2	2	1	0	2	1	2	0	..	1	4	1
Feb. 19	83	71	77	1	3	0	3	1	..	3	3	1	3	3	3	2	2	..	0	3	4
Feb. 20	90	72	81	0	1	0	0	3	..	0	2	1	1	0	2	0	0	..	3	0	3
Feb. 21	80	75	77.5	2	0	0	3	0	..	3	3	L	3	1	1	5	3	..	2	2	2
Feb. 22	86	63	74.5	2	1	0	3	0	..	1	2	..	2	1	1	1	2	..	1	1	3
Feb. 23	87	71	79	1	0	0	2	0	..	1	1	..	1	1	1	1	1	..	0	0	2
Feb. 24	74	71	72.5	1	2	0	0	2	..	2	1	..	2	3	3	1	1	..	1	2	3
Feb. 25	90	75	82.5	1	3	0	2	1	..	2	2	..	1	1	2	1	1	..	2	1	1
Feb. 26	86	80	83	2	1	0	2	2	..	2	2	..	3	2	3	3	0	..	0	2	3
Feb. 27	89	75	82	3	1	0	2	0	..	2	2	..	2	2	3	2	4	..	2	2	4
Feb. 28	89	74	81.5	2	1	0	1	2	..	1	3	..	2	2	2	3	2	..	1	1	3
March 1	84	74	79	5	4	0	4	3	..	3	3	..	4	4	3	4	1	..	2	3	4
March 2	89	75	82	4	3	0	3	2	..	2	2	..	4	3	2	4	1	..	2	2	3

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number																
	Max.	Min.	Mean	1	2	3	4	5	7	8	10	11	12	13	14	16	17	18	19	20
1919																				
March 3	95	85	90	5	3	0	4	3	2	4	5	5	5	5	0	1	3	0	..	..
March 4	101	84	92.5	3	3	D	2	0	3	4	4	2	5	5	0	0	4	6	..	..
March 5	98	82	90	6	1	..	2	4	3	4	2	2	3	2	1	0	4	4	..	..
March 6	90	77	83.5	3	3	..	4	2	3	1	3	4	4	2	1	0	0	3	..	..
March 7	90	77	83.5	1	1	..	1	1	1	3	2	1	3	1	0	1	2	3	..	..
March 8	85	80	82.5	2	1	..	1	2	2	0	1	2	2	2	1	1	2	2	..	..
March 9	80	73	76.5	1	0	..	0	2	1	0	1	1	2	2	0	0	1	2	..	..
March 10	77	72	74.5	3	2	..	2	1	2	1	1	0	3	2	0	0	1	2	..	..
March 11	85	73	79	2	1	..	2	1	2	0	2	0	2	2	1	0	3	1	..	..
March 12	85	77	81	4	1	..	1	3	1	0	2	0	2	2	1	0	2	2	..	..
March 13	78	77	77.5	3	2	..	4	1	2	0	2	0	4	2	1	1	1	4	..	..
March 14	86	77	81.5	2	1	..	1	2	2	0	2	1	2	2	1	0	1	2	..	..
March 15	82	80	81	2	2	..	3	2	2	0	3	0	4	3	2	1	2	3	..	..
March 16	83	80	81.5	2	2	..	3	2	2	0	3	0	3	2	2	0	1	2	..	..
March 17	81	78	79.5	1	1	..	1	0	2	0	1	0	3	2	2	0	0	1	..	..
March 18	84	73	78.5	2	1	..	1	2	0	0	2	0	2	1	0	0	1	2	..	..
March 19	78	74	76	2	1	..	1	1	1	0	2	0	3	2	0	1	2	2	..	..
March 20	78	75	76.5	1	0	..	1	1	3	0	2	0	2	1	0	1	2	3	..	..
March 21	83	71	77	2	1	..	2	1	0	0	2	0	1	3	2	0	1	2	..	..
March 22	86	78	82	3	2	..	2	2	2	0	3	0	3	2	2	2	2	2	..	..
March 23	81	78	79.5	2	2	..	2	2	2	0	3	0	3	2	1	2	2	1	..	..
March 24	80	76	78	2	2	..	1	3	1	0	1	0	2	2	1	0	1	3	..	..
March 25	80	79	79.5	2	1	..	1	1	0	0	3	0	1	1	0	0	1	2	..	..
March 26	79	75	77	1	1	..	1	2	3	0	0	0	1	2	0	0	0	0	..	..
March 27	77	71	74	3	3	..	2	1	2	0	4	0	3	1	2	0	1	4	..	..
March 28	86	72	79	1	1	..	1	1	1	0	1	0	3	1	1	0	1	2	..	..
March 29	88	78	83	3	1	..	3	1	3	0	3	0	2	3	1	0	2	2	..	..
March 30	80	76	78	2	1	..	2	1	2	0	2	0	2	2	0	0	2	2	..	..
March 31	84	76	80	1	0	..	1	1	1	0	1	0	1	1	0	2	1	1	..	..
April 1	85	75	80	1	0	..	1	2	1	0	1	0	1	2	0	0	1	0	..	..
April 2	83	75	79	2	0	..	2	0	1	0	2	0	2	1	0	2	0	3	..	..
April 3	77	73	75	1	0	..	3	2	1	0	2	D	2	3	0	0	2	1	..	..
April 4	85	75	80	0	0	..	0	1	0	0	2	..	2	0	0	0	0	0	..	..
April 5	84	75	79.5	2	0	..	4	3	3	D	3	..	4	4	1	D	3	4	..	..
April 6	82	78	80	2	0	..	4	2	2	..	2	..	3	3	1	..	3	3	..	..
April 7	84	81	82.5	2	0	..	0	3	2	..	2	..	3	2	0	..	3	2	M	..
April 8	88	83	85.5	3	0	..	3	3	2	..	1	..	2	3	1	..	2	2	1	M
April 9	86	81	83.5	2	0	..	3	2	1	..	1	..	1	2	0	..	2	2	0	0
April 10	86	71	78.5	2	0	..	2	2	2	..	0	..	2	2	0	..	1	1	1	0

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number												
	Max.	Min.	Mean	1	2	4	5	7	10	12	13	14	17	18	19	20
1919																
April 11	87	70	78.5	1	0	2	2	0	0	2	2	0	1	3	0	0
April 12	90	73	81.5	3	0	3	3	1	0	3	4	0	2	2	2	0
April 13	93	77	85	2	0	2	2	0	0	2	3	0	1	2	2	0
April 14	95	81	88	1	D	3	2	0	0	4	3	0	2	4	2	0
April 15	88	80	84	4	..	1	2	0	0	4	2	0	2	0	0	0
April 16	92	80	86	1	..	1	1	0	D	1	2	0	0	2	3	5
April 17	87	72	79.5	0	..	0	1	0	..	2	2	0	0	2	5	2
April 18	87	75	81	2	..	2	1	0	..	3	1	D	1	2	4	4
April 19	90	77	83.5	0	..	1	2	0	..	3	3	..	1	3	2	1
April 20	90	79	84.5	0	..	1	2	0	..	3	2	..	1	2	2	1
April 21	89	80	84.5	0	..	2	3	0	..	2	3	..	3	2	4	2
April 22	90	77	83.5	0	..	2	2	0	..	3	4	..	2	2	4	1
April 23	88	80	84	0	..	2	2	0	..	3	3	..	3	3	1	6
April 24	90	80	85	0	..	2	4	0	..	2	4	..	1	3	4	4
April 25	90	77	83.5	D	..	3	2	0	..	5	3	..	2	2	1	2
April 26	89	81	85	..	..	4	5	1	..	5	4	..	3	3	4	4
April 27	87	78	82.5	..	..	3	4	1	..	4	3	..	2	2	4	4
April 28	93	85	89	..	..	4	3	0	..	2	4	..	4	3	3	3
April 29	90	84	87	..	..	4	0	0	..	3	2	..	2	2	2	2
April 30	89	76	82.5	..	..	3	0	0	..	3	4	..	4	4	4	4
May 1	87	78	82.5	..	..	3	0	0	..	3	4	..	3	3	3	4
May 2	93	80	86.5	..	..	6	L	0	..	5	5	..	5	5	1	5
May 3	92	85	88.5	..	..	4	..	4	..	5	3	..	4	4	3	4
May 4	89	82	85.5	..	..	3	..	3	..	5	3	..	3	4	3	3
May 5	90	86	88	..	..	4	..	2	..	4	3	..	1	2	3	3
May 6	88	84	86	..	..	1	..	2	..	2	3	..	2	3	2	3
May 7	85	75	80	..	..	2	..	3	..	2	1	..	4	1	2	4
May 8	81	78	79.5	..	..	2	..	1	..	2	3	..	2	1	2	1
May 9	78	76	77	..	..	1	..	2	..	2	2	..	1	1	2	1
May 10	78	75	76.5	..	..	1	..	2	..	2	1	..	1	1	1	1
May 11	78	71	74.5	..	..	2	..	2	..	2	1	..	1	0	1	1
May 12	81	77	79	..	..	3	..	1	..	2	2	..	1	2	2	1
May 13	90	75	82.5	..	..	2	..	3	..	2	2	..	1	1	2	2
May 14	94	85	89.5	..	..	2	..	2	..	2	4	..	3	1	4	3
May 15	92	86	89	..	..	5	..	4	..	4	4	..	4	3	4	5
May 16	97	87	92	..	..	0	..	3	..	1	5	..	2	4	3	4
May 17	100	87	93.5	..	..	4	..	4	..	0	5	..	3	4	6	3
May 18	98	80	89	..	..	4	..	3	..	0	5	..	3	3	5	2
May 19	91	85	88	..	..	4	..	4	..	1	3	..	3	1	5	4

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number									
	Max.	Min.	Mean	4	7	12	13	17	18	19	20	21	22
1919													
May 20	88	80	84	4	1	0	2	3	4	3	1	....	....
May 21	93	76	84.5	0	4	0	2	1	2	2	4	....	....
May 22	92	77	84.5	7	4	0	5	2	3	5	3	....	....
May 23	93	80	86.5	2	0	0	0	0	2	4	4	....	....
May 24	87	85	86	1	3	0	5	0	3	3	4	....	....
May 25	93	78	85.5	1	2	0	5	L	3	3	3	....	....
May 26	86	82	84	4	3	0	5	....	4	5	4	M	....
May 27	85	82	83.5	3	4	0	3	....	3	4	4	0	....
May 28	94	81	87.5	4	6	0	5	....	4	4	5	8	....
May 29	90	81	85.5	3	4	0	4	....	3	6	2	2	....
May 30	91	79	85	2	2	0	4	....	4	2	1	5	M
May 31	90	76	83	2	4	0	4	....	6	8	4	4	2
June 1	88	82	85	1	2	0	3	....	3	2	4	3	2
June 2	93	85	89	4	1	0	1	....	2	2	3	0	3
June 3	90	77	83.5	0	2	0	5	....	0	2	2	1	2
June 4	90	80	85	0	3	0	4	....	5	2	4	0	2
June 5	91	80	85.5	0	2	0	2	....	3	3	4	1	4
June 6	96	80	88	0	3	0	2	....	3	1	1	5	0
June 7	96	85	90.5	1	3	0	6	....	4	3	2	4	4
June 8	100	85	92.5	1	2	0	5	....	3	2	2	4	4
June 9	101	91	96	0	2	D	4	....	5	7	6	10	7
June 10	90	83	86.5	0	0	....	4	....	3	3	1	0	1
June 11	89	76	82.5	0	0	....	2	....	2	2	3	4	1
June 12	96	85	90.5	D	2	....	3	....	2	3	2	1	3
June 13	95	85	90	....	1	....	3	....	2	2	1	2	3
June 14	95	85	90	....	1	....	4	....	0	4	3	2	3
June 15	92	83	87.5	....	0	....	3	....	0	3	2	2	2
June 16	86	80	83	....	0	....	3	....	3	4	1	4	3
June 17	89	85	87	....	2	....	2	....	1	6	5	5	4
June 18	91	87	89	....	1	....	6	....	1	4	2	3	0
June 19	92	88	90	....	1	....	2	....	0	5	2	4	3
June 20	93	89	91	....	0	....	2	....	0	4	2	3	3
June 21	94	85	89.5	....	2	....	5	....	0	5	3	5	3
June 22	92	81	86.5	....	1	....	4	....	0	4	3	5	3
June 23	91	83	87	....	0	....	2	....	0	4	5	1	3
June 24	93	85	89	....	0	....	2	....	0	3	4	0	2
June 25	92	85	88.5	....	3	....	1	....	5	4	5	4	6
June 26	92	85	88.5	....	2	....	5	....	0	9	5	3	6
June 27	92	85	88.5	....	0	....	3	....	0	2	3	3	3

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number															
	Max.	Min.	Mean	7	13	18	19	20	21	22	23	24	25	26	27	28	29	30	31
1919																			
June 28	92	84	88	4	2	1	5	3	2	5	..	..	M	..	..	..	..	..	..
June 29	93	87	90	3	2	1	5	2	2	4	..	..	0	..	..	..	..	..	..
June 30	95	88	91.5	2	5	0	3	2	2	4	..	..	0	..	..	..	..	..	..
July 1	96	90	93	0	5	3	3	5	3	4	..	..	1	..	..	..	..	..	..
July 2	96	91	93.5	3	3	2	5	4	2	4	M	..	3	..	..	..	..	..	..
July 3	96	94	95	1	2	0	4	2	3	4	0	..	1	..	..	..	..	..	..
July 4	97	90	93.5	1	2	0	4	1	3	4	0	..	0	..	..	..	..	..	..
July 5	97	93	95	0	3	1	2	4	4	4	1	M	0	..	..	..	..	..	..
July 6	97	90	93.5	0	3	0	2	3	3	3	0	0	0	..	..	..	..	..	..
July 7	96	89	92.5	7	3	6	2	0	2	3	1	0	0	..	..	..	..	..	..
July 8	95	85	90	2	2	0	2	2	3	3	0	11	0	..	..	..	..	..	..
July 9	97	91	94	0	1	1	2	1	4	2	1	3	0	..	..	..	..	..	..
July 10	98	90	94	1	1	1	2	0	1	3	0	3	0	..	..	..	..	..	..
July 11	100	91	95.5	0	2	2	2	0	1	2	0	1	0	..	..	..	..	..	..
July 12	99	94	96.5	1	2	0	2	0	3	3	0	0	0	..	..	..	..	..	..
July 13	99	97	98	0	1	0	2	0	3	2	0	0	0	..	..	..	..	..	..
July 14	100	98	99	1	2	0	2	0	3	2	0	1	0	..	..	..	..	..	..
July 15	99	94	96.5	0	1	0	3	0	3	1	0	0	0	..	..	..	..	..	..
July 16	100	92	96	0	1	0	1	0	4	4	0	0	0	..	..	..	..	..	..
July 17	101	91	96	0	0	0	3	0	1	1	1	0	0	..	..	..	..	..	..
July 18	96	90	93	0	3	0	1	0	5	4	0	0	0	..	..	..	..	..	..
July 19	95	87	91	D	2	D	1	D	4	3	0	0	0	..	..	..	..	..	..
July 20	96	93	94.5	..	2	..	0	..	4	2	0	0	0	..	..	..	..	..	..
July 21	96	93	94.5	..	2	..	0	..	5	6	2	0	0	..	..	..	..	..	..
July 22	94	92	93	..	1	..	0	..	5	5	1	0	0	..	..	..	..	..	..
July 23	92	90	91	..	3	..	0	..	5	7	3	1	0	..	..	..	..	..	..
July 24	90	86	88	..	2	..	D	..	4	0	2	3	D	..	..	..	..	..	..
July 25	96	87	91.5	..	3	..	..	..	4	2	3	2	..	..	..	..	..	..	..
July 26	97	89	93	..	1	..	..	..	5	5	4	3	..	..	..	..	..	..	..
July 27	96	90	93	..	1	..	..	..	4	5	4	3	..	..	..	..	..	..	..
July 28	95	85	90	..	0	..	..	..	2	3	3	0	..	..	..	..	..	..	..
July 29	96	91	93.5	..	2	..	..	..	7	4	3	1	..	..	..	..	..	..	..
July 30	98	91	94.5	..	0	..	..	..	5	0	3	2	..	..	..	..	..	M	M
July 31	97	92	94.5	..	2	..	..	..	7	3	4	2	..	..	..	..	..	0	0
Aug. 1	97	92	94.5	..	1	..	..	..	3	4	2	2	..	..	..	..	..	1	4
Aug. 2	97	92	94.5	..	1	..	..	..	7	2	4	3	..	..	..	..	..	4	3
Aug. 3	96	90	93	..	0	..	..	..	5	4	5	4	..	M	M	M	M	1	3
Aug. 4	97	92	94.5	..	0	..	..	..	6	4	6	2	..	0	0	0	0	2	6
Aug. 5	97	92	94.5	..	D	..	..	..	1	0	2	2	..	0	0	0	0	0	1

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number															
	Max.	Min.	Mean	21	22	23	24	26	27	28	29	30	31	32	33	34	35	36	37
1919																			
Aug. 6	97	91	94	0	4	3	2	0	0	0	0	0	3	..	..	..	..	..	..
Aug. 7	96	90	93	4	5	0	2	0	0	0	0	1	0	..	..	..	..	..	..
Aug. 8	97	90	93.5	3	2	2	3	1	0	0	0	0	0	..	..	..	..	..	..
Aug. 9	98	90	94	2	0	3	5	0	0	0	0	0	0	..	..	..	..	..	..
Aug. 10	97	90	93.5	2	0	3	5	0	0	0	0	1	0	..	..	..	..	..	..
Aug. 11	95	93	94	4	0	0	4	0	0	0	0	0	1	..	..	..	..	..	..
Aug. 12	93	88	90.5	5	0	0	0	0	0	0	0	0	1	..	..	..	..	..	..
Aug. 13	94	88	91	4	D	D	7	0	0	0	0	L	0	..	..	..	..	..	..
Aug. 14	95	88	91.5	4	..	..	3	0	0	0	0	..	0	..	..	..	..	..	..
Aug. 15	95	90	92.5	5	..	..	4	0	0	0	0	..	0	..	..	..	..	..	..
Aug. 16	95	90	92.5	2	..	..	5	0	0	0	0	..	0	..	..	..	..	..	..
Aug. 17	94	90	92	1	..	..	5	0	0	0	0	..	0	..	..	..	..	..	..
Aug. 18	94	91	92.5	1	..	..	1	0	0	0	0	..	0	..	..	..	..	..	..
Aug. 19	95	85	90	4	..	..	4	1	2	1	0	..	D	..	..	..	..	..	..
Aug. 20	92	87	89.5	3	..	..	2	0	0	0	0	..	..	..	..	..	..	..	..
Aug. 21	90	85	87.5	2	..	..	3	0	0	0	0	..	..	..	..	..	..	..	..
Aug. 22	90	84	87	3	..	..	3	0	0	0	0	..	..	..	..	..	..	..	..
Aug. 23	85	81	83	2	..	..	3	0	0	0	0	..	..	..	..	..	..	..	..
Aug. 24	87	85	86	2	..	..	2	0	0	0	0	..	..	..	..	..	..	..	..
Aug. 25	88	86	87	3	..	..	4	6	D	7	13	..	..	..	..	..	..	..	..
Aug. 26	91	80	85.5	1	..	..	4	0	..	2	3	..	..	..	..	..	..	..	..
Aug. 27	90	82	86	2	..	..	3	0	..	0	3	..	..	..	..	..	..	..	..
Aug. 28	91	85	88	2	..	..	4	0	..	0	3	..	..	..	..	..	..	..	..
Aug. 29	93	87	90	2	..	..	4	0	..	0	3	..	..	M	..	..	..	..	..
Aug. 30	94	90	92	4	..	..	5	0	..	4	4	..	..	0	M	..	..	..	..
Aug. 31	93	87	90	4	..	..	4	0	..	3	4	..	..	0	0	..	..	..	..
Sept. 1	95	87	91	3	..	..	4	0	..	3	3	..	..	0	0	..	..	..	..
Sept. 2	90	78	84	3	..	..	3	2	..	0	3	..	..	0	0	..	..	..	..
Sept. 3	87	77	82	4	..	..	3	0	..	5	4	..	..	0	0	M	M	M	..
Sept. 4	85	80	82.5	4	..	..	5	0	..	0	4	..	..	0	0	0	0	0	..
Sept. 5	87	82	84.5	5	..	..	5	0	..	6	3	..	..	0	0	0	0	0	..
Sept. 6	89	80	84.5	5	..	..	5	6	..	3	5	..	..	0	0	0	0	0	..
Sept. 7	85	80	82.5	5	..	..	4	5	..	3	4	..	..	0	0	0	0	0	..
Sept. 8	86	84	85	3	..	..	4	2	..	3	2	..	..	0	0	0	0	0	M
Sept. 9	90	85	87.5	5	..	..	4	4	..	2	7	..	..	0	0	0	0	0	0
Sept. 10	95	86	90.5	4	..	..	2	5	..	3	3	..	..	0	0	7	0	10	1
Sept. 11	95	87	91	4	..	..	1	3	..	3	3	..	..	0	0	0	0	0	0
Sept. 12	96	87	91.5	1	..	..	3	5	..	2	1	..	..	0	0	0	0	3	0
Sept. 13	97	80	88.5	4	..	..	2	3	..	3	3	..	..	0	0	0	0	3	0

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number																
	Max.	Min.	Mean	21	24	26	28	29	32	33	34	35	36	37	38	39	40	41	42	43
1919																				
Sept. 14	92	77	84.5	3	2	3	3	3	0	0	0	0	3	0	..	..	..	..	..	..
Sept. 15	90	80	85	3	1	2	2	2	0	0	4	0	2	10	..	..	..	..	..	..
Sept. 16	89	82	85.5	6	4	3	3	3	0	0	0	0	0	0	..	..	..	..	..	..
Sept. 17	87	83	85	0	5	3	4	1	0	0	0	0	6	7	..	..	..	..	..	..
Sept. 18	89	83	86	4	3	3	2	2	0	0	0	0	3	3	..	..	..	..	..	..
Sept. 19	90	85	87.5	5	2	3	3	3	0	0	0	0	0	0	..	..	..	..	..	..
Sept. 20	91	86	88.5	3	4	3	3	3	0	0	0	0	5	0	..	..	..	..	..	..
Sept. 21	89	86	87.5	3	4	2	2	2	0	0	0	0	5	8	..	..	..	..	..	..
Sept. 22	89	87	88	2	2	3	1	1	0	0	0	0	0	0	..	..	..	..	..	..
Sept. 23	84	76	80	2	0	2	2	0	0	0	0	3	0	0	..	..	..	..	..	..
Sept. 24	77	75	76	2	5	1	0	3	3	10	0	1	5	4	..	..	..	..	..	..
Sept. 25	85	74	79.5	0	4	3	4	0	0	2	D	0	2	4	..	..	..	..	..	..
Sept. 26	81	75	78	5	4	3	3	2	0	0	..	0	2	2	..	..	..	..	..	..
Sept. 27	83	75	79	2	5	3	0	2	1	6	..	3	5	4	..	..	..	..	..	..
Sept. 28	89	81	85	1	5	2	0	1	1	5	..	3	5	4	..	..	..	..	..	..
Sept. 29	92	83	87.5	3	3	5	7	3	0	4	..	2	5	4	..	..	..	..	..	..
Sept. 30	96	80	88	5	2	3	2	3	3	3	..	1	5	5	..	..	..	..	..	..
Oct. 1	94	80	87	3	6	5	5	3	0	0	..	0	3	5	..	..	..	..	..	..
Oct. 2	94	83	88.5	2	5	3	5	5	4	6	..	0	0	3	..	..	..	..	..	..
Oct. 3	89	82	85.5	1	3	0	4	1	2	0	..	0	8	0	M	M	M	..	..	..
Oct. 4	92	83	87.5	0	4	6	4	1	3	4	..	0	4	7	2	1	2	..	..	..
Oct. 5	93	82	87.5	0	3	5	3	1	3	4	..	0	3	6	1	0	1	..	..	..
Oct. 6	91	82	86.5	0	3	0	4	2	3	0	..	D	3	2	0	0	0	..	..	..
Oct. 7	85	80	82.5	0	2	5	0	3	0	8	..	..	0	3	5	2	3	..	..	..
Oct. 8	90	82	86	0	2	2	D	2	0	0	..	..	2	0	2	4	4	M	M	M
Oct. 9	90	84	87	3	4	7	..	5	8	9	..	..	5	5	7	3	3	2	0	5
Oct. 10	91	86	88.5	3	4	6	..	4	1	5	..	..	3	3	5	5	6	5	3	3
Oct. 11	88	78	83	1	2	3	..	2	0	3	..	..	3	1	4	2	4	2	1	2
Oct. 12	79	75	77	1	2	3	..	1	0	3	..	..	2	0	3	1	3	1	0	2
Oct. 13	76	74	75	3	3	2	..	3	0	2	..	..	4	2	3	2	3	2	0	3
Oct. 14	75	74	74.5	2	2	2	..	2	0	2	..	..	3	1	3	1	2	2	0	2
Oct. 15	78	74	76	1	0	3	..	3	0	1	..	..	3	0	2	4	4	0	0	3
Oct. 16	81	79	80	0	2	3	..	3	0	3	..	..	0	0	2	2	3	3	D	1
Oct. 17	81	73	77	1	2	2	..	2	0	2	..	..	2	D	0	0	0	0	..	1
Oct. 18	73	69	71	0	0	3	..	2	0	2	..	..	3	..	3	2	3	2	..	2
Oct. 19	75	70	72.5	0	0	2	..	1	0	1	..	..	2	..	2	1	2	1	..	1
Oct. 20	75	72	73.5	3	0	D	..	0	0	1	..	..	3	..	4	1	3	0	..	3
Oct. 21	82	75	78.5	1	0	..	..	0	0	2	..	..	3	..	2	2	5	0	..	4
Oct. 22	84	79	81.5	3	0	..	..	8	1	2	..	..	4	..	5	4	3	3	..	6

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number																
	Max.	Min.	Mean	21	24	29	32	33	36	38	39	40	41	43	44	45	46	47	48	49
1919																				
Oct. 23	87	83	85	0	0	9	1	4	4	4	5	6	3	4	..	..	..	..	..	..
Oct. 24	90	84	87	0	0	4	0	1	3	3	D	4	4	4	..	..	..	..	..	..
Oct. 25	90	85	87.5	4	0	5	1	6	5	3	..	5	5	7	..	..	..	..	..	..
Oct. 26	89	86	87.5	3	0	5	0	6	5	2	..	4	5	7	..	..	..	..	..	..
Oct. 27	88	86	87	2	0	4	0	4	4	3	..	4	6	4	..	..	..	..	..	..
Oct. 28	90	80	85	0	0	1	4	0	3	0	..	2	1	4	..	..	..	..	..	..
Oct. 29	80	77	78.5	1	0	1	0	2	2	0	..	2	5	2	..	..	..	..	..	..
Oct. 30	79	73	76	1	0	3	0	4	3	2	..	3	5	3	..	..	..	..	..	..
Oct. 31	84	79	81.5	2	0	4	0	2	5	1	..	4	4	2	..	..	..	..	..	..
Nov. 1	87	75	81	2	0	3	1	2	0	0	..	1	2	2	..	..	..	..	..	..
Nov. 2	79	73	76	2	0	2	1	1	0	0	..	1	2	2	..	..	..	..	..	..
Nov. 3	74	73	73.5	0	0	2	0	0	1	0	..	0	0	3	..	..	..	..	..	..
Nov. 4	79	73	76	2	0	2	0	3	4	0	..	0	0	1	..	..	..	..	..	..
Nov. 5	78	72	75	1	0	3	0	3	2	1	..	0	0	4	..	..	..	..	..	..
Nov. 6	82	74	78	1	0	3	0	2	1	0	..	0	0	4	..	..	..	..	..	..
Nov. 7	84	76	80	0	0	2	0	3	4	0	..	0	6	3	..	..	..	..	..	..
Nov. 8	88	76	82	1	0	4	0	4	3	0	..	D	5	5	..	..	..	..	..	..
Nov. 9	94	80	87	1	0	4	0	4	2	0	..	..	5	5	..	..	..	..	..	..
Nov. 10	92	81	86.5	0	0	2	0	3	3	0	..	..	2	3	..	..	..	..	..	..
Nov. 11	84	76	80	0	D	3	0	4	2	0	..	..	0	3	..	..	..	..	..	..
Nov. 12	81	74	77.5	7	..	2	0	3	2	0	..	..	0	2	..	..	..	..	..	..
Nov. 13	82	75	78.5	1	..	2	0	0	3	0	..	..	5	0	..	..	..	..	..	..
Nov. 14	82	66	74	2	..	3	0	0	3	0	..	..	0	0	..	..	..	..	..	..
Nov. 15	83	76	79.5	0	..	3	0	4	3	0	..	..	0	D	..	..	..	..	..	..
Nov. 16	79	75	77	0	..	2	0	3	2	0	..	..	0	..	..	..	..	..	..	..
Nov. 17	82	75	78.5	4	..	3	0	2	3	4	..	..	2	..	..	..	..	..	..	..
Nov. 18	83	76	79.5	0	..	3	0	0	2	1	..	..	0	..	..	..	..	..	..	..
Nov. 19	83	79	81	0	..	3	0	2	3	0	..	..	0	..	..	..	..	..	..	..
Nov. 20	80	75	77.5	0	..	5	0	3	2	0	..	..	0	..	..	..	..	..	..	..
Nov. 21	82	77	79.5	4	..	3	0	3	3	0	..	..	0	..	..	..	..	..	..	..
Nov. 22	84	78	81	0	..	4	1	3	3	2	..	..	0	..	..	..	..	M	..	..
Nov. 23	86	78	82	0	..	3	1	2	2	1	..	..	0	..	..	..	..	0	..	..
Nov. 24	87	83	85	0	..	3	0	3	4	3	..	..	0	..	M	M	M	0	M	M
Nov. 25	88	82	85	0	..	5	0	3	4	0	..	..	0	..	0	0	0	0	0	0
Nov. 26	89	81	85	0	..	0	0	1	1	0	..	..	0	..	0	0	0	0	0	0
Nov. 27	80	73	76.5	0	..	0	0	1	1	0	..	..	0	..	1	3	1	6	8	1
Nov. 28	73	69	71	0	..	0	0	1	1	0	..	..	0	..	1	2	1	3	1	1
Nov. 29	79	70	74.5	0	..	4	0	1	1	0	..	..	0	..	1	1	0	2	1	1
Nov. 30	79	66	72.5	0	..	4	0	1	1	0	..	..	0	..	4	0	2	2	1	2

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number												
	Max.	Min.	Mean	21	29	32	33	36	38	41	44	45	46	47	48	49
1919																
Dec 1	72	68	70	0	1	0	1	2	0	0	0	4	0	1	2	0
Dec. 2	76	70	73	0	1	0	1	0	0	0	1	0	0	0	0	1
Dec. 3	71	64	67.5	0	1	0	0	2	0	0	2	2	3	2	2	4
Dec. 4	78	65	71.5	0	2	0	0	2	0	0	3	2	3	2	3	3
Dec. 5	79	70	74.5	0	2	0	0	2	0	0	3	2	2	1	2	2
Dec. 6	88	76	82	0	6	0	5	3	1	0	5	5	2	1	5	6
Dec. 7	94	83	88.5	0	5	0	4	2	0	0	5	5	2	1	4	5
Dec. 8	87	74	80.5	D	3	0	4	3	0	0	6	9	7	3	5	4
Dec. 9	91	75	83	..	2	0	3	0	0	0	2	3	0	0	2	0
Dec. 10	79	72	75.5	..	2	0	1	4	0	0	0	2	2	0	3	3
Dec. 11	80	68	74	..	2	0	1	3	0	0	1	4	3	2	0	0
Dec. 12	87	72	79.5	..	2	0	3	2	0	0	3	3	3	0	7	0
Dec. 13	81	60	70.5	..	0	0	1	0	0	0	0	1	0	1	1	4
Dec. 14	73	66	69.5	..	0	0	0	0	0	0	0	0	0	1	0	4
Dec. 15	65	63	64	..	3	0	0	2	0	0	0	2	3	0	2	0
Dec. 16	75	66	70.5	..	2	0	0	0	0	0	4	2	2	0	3	3
Dec. 17	80	75	77.5	..	3	0	0	0	0	3	4	4	2	0	4	0
Dec. 18	89	74	81.5	..	3	0	3	0	0	0	4	4	4	6	0	0
Dec. 19	93	77	85	..	3	0	4	5	0	0	0	5	2	2	9	10
Dec. 20	93	77	85	..	4	0	3	3	0	0	6	5	3	6	2	6
Dec. 21	86	73	79.5	..	4	0	3	3	0	0	6	5	2	7	1	6
Dec. 22	86	74	80	..	4	0	3	3	D	0	0	4	0	3	3	4
Dec. 23	86	73	79.5	..	4	0	1	1	..	0	3	2	0	3	3	0
Dec. 24	84	75	79.5	..	0	0	1	1	..	0	3	2	0	3	3	1
Dec. 25	82	66	74	..	1	3	2	2	..	0	3	2	1	3	3	1
Dec. 26	77	56	66.5	..	1	0	1	2	..	0	0	2	0	2	1	1
Dec. 27	79	72	75.5	..	1	0	2	2	..	0	1	3	0	2	1	0
Dec. 28	81	78	79.5	..	0	0	2	4	..	0	1	3	0	1	1	0
Dec. 29	83	80	81.5	..	3	0	4	3	..	0	2	2	0	4	4	3
Dec. 30	84	81	82.5	..	4	0	3	3	..	0	4	3	0	0	2	3
Dec. 31	86	83	84.5	..	2	0	2	2	..	0	2	3	0	2	0	3
1920																
Jan. 1	88	81	84.5	..	2	0	2	1	..	0	3	3	0	3	2	3
Jan. 2	81	77	79	..	2	0	2	1	..	0	3	3	0	3	2	3
Jan. 3	78	74	76	..	2	0	2	1	..	0	4	4	0	2	2	3
Jan. 4	80	76	78	..	2	1	2	2	..	0	4	4	0	2	2	3
Jan. 5	80	72	76	..	0	0	0	1	..	0	1	2	0	1	3	3
Jan. 6	75	71	73	..	0	0	1	3	..	0	0	0	0	1	1	0
Jan. 7	78	73	75.5	..	0	0	1	0	..	0	0	0	0	2	3	0
Jan. 8	80	74	77	..	0	0	2	2	..	0	0	3	0	2	0	0

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number														
	Max.	Min.	Mean	29	32	33	36	41	44	45	46	47	48	49	50	51	52	53
1920																		
Jan. 9	77	72	74.5	0	3	1	2	1	0	2	2	1	1	0	..	..	..	..
Jan. 10	78	74	76	0	1	2	1	1	0	0	0	0	3	2	..	..	..	..
Jan. 11	83	78	80.5	1	1	1	1	1	0	0	1	0	2	2	..	..	..	..
Jan. 12	80	75	77.5	4	0	4	4	0	4	5	0	0	2	3	..	..	..	..
Jan. 13	88	75	81.5	3	0	4	4	0	3	4	0	0	1	2	..	..	..	..
Jan. 14	93	74	83.5	3	0	5	3	0	3	0	0	5	0	3	..	..	..	..
Jan. 15	90	76	83	3	0	10	3	0	0	0	0	3	6	0	..	..	..	..
Jan. 16	95	78	86.5	4	0	5	0	0	0	0	0	5	3	4	..	..	..	..
Jan. 17	96	78	87	3	0	5	0	0	0	0	0	5	3	4	..	..	..	..
Jan. 18	95	79	87	3	0	4	1	0	7	0	0	6	4	5	..	..	..	..
Jan. 19	94	84	89	3	0	4	0	0	0	17	0	4	4	4	..	..	..	..
Jan. 20	88	80	84	2	0	2	0	0	4	3	0	6	4	4	M	M	M	M
Jan. 21	90	82	86	0	0	0	0	0	2	1	0	2	0	1	0	0	0	0
Jan. 22	83	70	76.5	2	0	3	0	0	3	2	0	2	3	2	0	0	0	0
Jan. 23	83	72	77.5	2	0	2	0	0	2	1	0	1	2	1	0	0	0	0
Jan. 24	83	74	78.5	2	0	2	0	0	2	2	0	2	2	2	0	0	0	0
Jan. 25	76	73	74.5	1	0	1	0	0	2	2	0	2	1	1	0	0	0	0
Jan. 26	76	72	74	0	0	1	0	0	3	1	0	3	4	3	0	0	2	4
Jan. 27	82	73	77.5	2	0	1	0	0	2	0	0	2	0	2	0	0	0	1
Jan. 28	80	70	75	2	0	3	0	0	2	2	0	1	3	2	0	0	0	0
Jan. 29	85	64	74.5	2	0	2	0	0	1	1	1	1	3	2	0	0	0	0
Jan. 30	83	64	73.5	3	0	0	0	0	2	0	0	3	3	5	2	0	3	3
Jan. 31	87	72	79.5	4	0	0	0	0	5	3	2	5	4	5	0	0	0	0
Feb. 1	91	78	84.5	3	0	6	0	0	5	3	2	4	3	5	0	0	0	0
Feb. 2	93	73	83	4	0	6	0	0	2	2	0	2	3	3	6	5	7	4
Feb. 3	95	76	85.5	4	0	3	0	0	3	1	0	4	6	4	0	2	4	1
Feb. 4	89	74	81.5	3	0	3	0	0	3	1	0	4	5	4	0	2	4	1
Feb. 5	88	72	80	3	0	1	0	0	0	0	0	3	3	2	6	3	4	3
Feb. 6	90	73	81.5	3	0	4	0	0	D	0	0	3	2	4	4	3	0	1
Feb. 7	85	78	81.5	2	0	2	D	0	..	0	0	2	0	2	2	3	4	2
Feb. 8	79	70	74.5	2	0	1	..	0	..	0	0	2	0	2	2	2	3	1
Feb. 9	78	77	77.5	2	1	0	..	0	..	2	0	2	3	2	2	2	1	0
Feb. 10	81	71	76	2	0	2	..	0	..	1	0	3	3	3	1	3	3	2
Feb. 11	88	68	78	1	0	1	..	0	..	0	0	3	3	3	1	3	2	2
Feb. 12	83	70	76.5	1	0	0	..	0	..	0	0	1	0	0	0	0	1	0
Feb. 13	77	72	74.5	1	0	0	..	0	..	0	0	0	0	0	3	2	1	2
Feb. 14	82	71	76.5	0	0	0	..	0	..	1	0	1	0	1	1	0	0	0
Feb. 15	76	66	71	0	0	0	..	0	..	0	0	1	0	1	1	0	0	0
Feb. 16	69	58	63.5	0	0	D	..	0	..	0	0	3	0	0	0	0	2	2

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature			Pair Number											
	Max.	Min.	Mean	29	32	41	45	46	47	48	49	50	51	52	53
1920															
Feb. 17	74	67	70.5	2	0	0	0	0	2	0	0	3	0	0	2
Feb. 18	81	71	76	2	0	0	0	0	1	0	2	1	D	1	0
Feb. 19	79	74	76.5	1	0	0	0	0	1	0	2	1	..	1	0
Feb. 20	84	75	79.5	3	D	0	0	0	2	D	2	3	..	2	1
Feb. 21	82	73	77.5	3	..	0	0	0	1	..	2	2	..	1	1
Feb. 22	82	77	79.5	3	..	0	2	0	1	..	2	2	..	1	0
Feb. 23	82	79	80.5	0	..	0	2	0	1	..	1	2	..	1	0
Feb. 24	82	75	78.5	0	..	0	0	0	0	..	2	2	..	0	0
Feb. 25	79	70	74.5	2	..	0	0	0	0	..	2	0	..	2	0
Feb. 26	77	70	73.5	0	..	0	0	0	0	..	0	0	..	0	3
Feb. 27	73	68	70.5	2	..	0	0	0	0	..	1	0	..	1	1
Feb. 28	74	65	69.5	0	..	0	0	0	0	..	1	2	..	0	0
Feb. 29	78	65	71.5	0	..	0	0	0	0	..	0	1	..	0	0
March 1	65	61	63	0	..	0	0	0	1	..	1	2	..	0	0
March 2	71	64	67.5	0	..	0	0	0	0	..	1	1	..	0	0
March 3	77	66	71.5	2	..	0	0	0	0	..	1	0	..	1	0
March 4	79	67	73	0	..	0	0	0	0	..	0	0	..	0	1
March 5	72	63	67.5	1	..	0	0	0	0	..	0	3	..	0	0
March 6	71	62	66.5	0	..	0	0	0	0	..	0	0	..	0	0
March 7	69	58	63.5	0	..	0	0	0	0	..	0	0	..	0	0
March 8	59	55	57	1	..	0	0	0	0	..	0	0	..	0	0
March 9	78	62	70	1	..	0	0	0	0	..	2	5	..	1	0
March 10	90	78	84	2	..	0	0	0	0	..	3	1	..	1	0
March 11	86	79	82.5	3	..	0	0	0	0	..	3	3	..	0	4
March 12	91	78	84.5	1	..	0	0	0	0	..	1	2	..	0	2
March 13	92	78	85	1	..	0	0	0	0	..	2	2	..	0	2
March 14	92	77	84.5	1	..	0	0	0	0	..	2	4	..	0	1
March 15	81	78	79.5	0	..	0	0	0	0	..	0	4	..	0	0
March 16	83	81	82	0	..	0	0	0	0	..	4	2	..	0	0
March 17	84	80	82	0	..	0	0	0	0	..	4	0	..	0	4
March 18	87	81	84	0	..	D	0	0	0	..	0	2	..	0	0
March 19	86	83	84.5	0	..	..	0	0	0	..	1	1	..	0	0
March 20	87	76	81.5	D	..	..	0	0	0	..	0	0	..	0	0
March 21	87	76	81.5	..	..	..	0	0	0	..	0	0	..	0	0
March 22	79	74	76.5	..	..	..	0	3	0	..	3	3	..	5	5
March 23	86	76	81	..	..	..	0	0	0	..	3	1	..	5	0
March 24	81	75	78	..	..	..	3	0	0	..	4	4	..	0	1
March 25	86	78	82	..	..	..	0	0	0	..	4	2	..	0	2
March 26	87	79	83	..	..	..	0	0	0	..	2	3	..	0	0

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature Max.	Min.	Mean	Pair Number 45	46	47	49	50	52	53
1920										
March 27	85	79	82	0	0	0	0	3	2	1
March 28	84	76	80	0	0	0	0	2	1	0
March 29	83	77	80	3	0	0	8	1	0	0
March 30	82	76	79	1	0	1	1	4	1	2
March 31	82	75	78.5	0	0	0	0	3	1	1
April 1	84	77	80.5	0	0	0	2	1	1	2
April 2	87	74	80.5	0	0	0	2	0	0	2
April 3	79	73	76	0	0	0	1	1	0	2
April 4	81	73	77	0	0	0	2	1	0	1
April 5	72	68	70	0	0	0	2	1	0	2
April 6	75	71	73	0	0	0	1	1	0	2
April 7	83	74	78.5	0	0	0	1	1	0	2
April 8	83	78	80.5	0	0	0	2	3	1	4
April 9	85	78	81.5	0	0	0	2	3	1	2
April 10	85	81	83	0	0	0	1	3	1	2
April 11	83	81	82	0	0	0	1	3	0	4
April 12	85	77	81	0	0	0	2	2	1	2
April 13	83	75	79	0	0	0	1	2	1	3
April 14	79	73	76	0	0	0	1	2	1	2
April 15	81	78	79.5	0	0	0	1	2	0	3
April 16	84	79	81.5	0	0	0	1	2	0	4
April 17	94	83	88.5	0	0	0	1	2	0	2
April 18	90	85	87.5	0	0	0	2	2	0	2
April 19	89	83	86	0	0	0	5	2	0	2
April 20	88	82	85	0	0	0	1	2	0	2
April 21	86	80	83	0	0	0	1	2	0	3
April 22	90	82	86	0	0	0	1	2	0	2
April 23	89	82	85.5	0	0	0	1	2	0	2
April 24	85	82	83.5	0	0	0	1	2	0	2
April 25	85	80	82.5	0	0	0	1	2	D	2
April 26	86	80	83	0	0	0	1	2	....	1
April 27	80	73	76.5	0	0	0	0	0	....	0
April 28	76	73	74.5	0	0	0	0	0	....	0
April 29	82	76	79	0	0	0	0	0	....	0
April 30	86	79	82.5	0	0	0	0	0	....	0
May 1	87	82	84.5	0	0	0	0	0	....	0
May 2	90	84	87	0	0	0	0	0	....	0
May 3	91	87	89	0	0	0	0	0	....	0
May 4	94	87	90.5	0	0	0	0	0	....	0

M—Mated. D—Died. L—Lost.

Table 18—Rate of Oviposition—Continued

Date	Temperature Max.	Min.	Mean	Pair Number 45	46	47	49	50	53
1920									
May 5	93	86	89.5	0	0	0	0	0	0
May 6	92	86	89	D	0	0	0	0	0
May 7	93	86	89.5	....	0	0	0	0	0
May 8	92	86	89	....	0	0	0	0	0
May 9	93	86	89.5	....	0	0	0	0	0
May 10	92	86	89	....	0	0	0	0	0
May 11	90	86	88	....	0	0	0	0	0
May 12	91	87	89	....	0	0	0	0	0
May 13	93	88	90.5	....	0	0	0	0	0
May 14	96	87	91.5	....	0	0	0	0	0
May 15	87	79	83	....	0	0	0	0	0
May 16	84	80	82	....	0	0	0	0	0
May 17	81	78	79.5	....	0	0	0	0	0
May 18	81	75	78	....	0	0	0	0	0
May 19	85	80	82.5	....	0	0	0	0	0
May 20	90	84	87	....	0	0	0	0	0
May 21	90	86	88	....	0	0	0	0	0
May 22	92	87	89.5	....	0	0	0	0	0
May 23	92	87	89.5	....	0	0	0	0	0
May 24	93	89	91	....	0	0	0	0	0
May 25	93	87	90	....	0	0	0	0	0
May 26	94	90	92	....	0	0	0	0	0
May 27	97	90	93.5	....	0	0	0	0	0
May 28	95	87	91	....	0	0	0	0	0
May 29	92	86	89	....	0	0	0	0	0
May 30	94	86	90	....	0	0	0	0	0
May 31	94	92	93	....	0	0	0	0	0
June 1	92	87	89.5	....	0	0	0	0	0
June 2	87	81	84	....	0	0	0	0	0
June 3	93	86	89.5	....	0	0	0	0	0
June 4	94	87	90.5	....	0	0	0	0	0
June 5	95	86	90.5	....	0	0	0	0	0
June 6	93	84	88.5	....	0	0	0	0	0
June 7	93	87	90	....	0	0	0	D	0
June 8	93	85	89	....	0	0	0	....	0
June 9	92	85	88.5	....	0	0	0	....	D
June 10	92	83	87.5	....	0	0	D	....	....
June 11	93	88	90.5	....	0	0	....	....	....
June 12	92	89	90.5	....	0	0	....	....	....
June 13	93	86	89.5	....	0	0	....	....	....
June 14	96	90	93	....	0	0	....	....	....
June 15	94	85	89.5	....	0	0	....	....	....
June 16	97	91	94	....	0	D	....	....	....
June 17	95	89	92	....	0	....	....	....	....
June 18	90	84	87	....	0	....	....	....	....
June 19	89	81	85	....	0	....	....	....	....
June 20	87	81	84	....	0	....	....	....	....
June 21	92	88	90	....	0	....	....	....	....
June 22	95	89	92	....	D	....	....	....	....

M—Mated. D—Died. L—Lost.

Variations in temperature have a direct influence upon the rate of oviposition. When the mean average temperature falls below 70 degrees F. the rate at which eggs are deposited begins to decline, and egg deposition may cease entirely below 60 degrees F. The optimum mean temperature for the maximum rate of oviposition ranges from 78 to 95 degrees F.

The results given of the winter months are not comparable to the natural conditions, but rather approach the maximum figures. All observations made during the warm season, however, will nearly approximate the natural occurrence of the rate of oviposition, since these observations were made in an open laboratory where conditions close to the normal prevailed.

Table 19 Summary of Rate of Oviposition

Date	Temperature, mean	1	2	3	4	5	6	7	8	9	10	11	12	13	14	*15	16	17	18	19	20	21	22	23	24	*25	26	*27	28	29	*30	*31	32	33	*34
1918																																			
December	81.6	51	27	48	42	37	33	26	20	26	26	27	26	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
1919																																			
January	79.1	85	49	56	68	59	75	65	72	56	63	38	80	44	23	5	47	29	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
February	78.8	67	39	5	61	40	25	66	66	26	61	43	59	65	37	...	63	49	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
March	80.4	76	48	...	59	51	...	56	22	...	71	25	81	68	25	...	17	51	72	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
April	82.4	31	...	...	67	63	...	18	...	...	16	...	81	80	3	...	2	54	66	53	45	...	...	...	...	...	...	...	...	...	...	...	...	...	...
May	84.7	...	...	...	86	...	...	82	...	...	...	...	46	103	...	...	...	53	85	103	93	19	2	...	...	...	...	...	...	...	...	...	...	...	...
June	85.2	...	...	...	7	...	...	45	...	...	...	...	...	97	...	...	...	...	49	108	87	85	93	...	...	...	...	...	...	...	...	...	...	...	...
July	92.3	...	...	...	...	...	...	17	...	...	...	...	...	58	...	...	...	...	16	45	22	112	98	36	36	5	...	...	...	...	...	...	...	...	...
August	90.8	...	...	...	...	...	...	...	...	...	...	...	...	2	...	...	...	...	...	...	...	93	25	30	104	...	8	2	17	33	10	22	...	...	...
September	85.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	99	...	...	100	...	82	...	77	79	...	...	8	30	11
October	84.5	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	41	...	...	49	...	62	...	25	90	...	...	31	89	...
November	79.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	28	...	...	...	...	...	...	...	82	...	...	4	65	...
December	76.9	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	71	...	...	3	60	...
1920																																			
January	79.1	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	57	...	...	6	74	...
February	76.6	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	49	...	...	1	29	...
March	77.0	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	13	...	...	...	...	...

Table 19—Summary of Rate of Oviposition—Continued

Date	Temperature, mean	*35	36	37	38	*39	40	41	*42	43	44	45	46	47	48	49	50	*51	52	53
1919																				
September	85.1	13	69	56	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...
October	84.5	...	97	38	73	42	88	61	4	75	...	...	...	...	...	...	...	...	...	...
November	79.0	...	66	...	12	...	2	29	...	37	7	6	4	13	11	5	...	...	...	...
December	76.9	...	61	...	1	...	...	3	...	...	74	95	46	59	78	77	...	...	...	...
1920																				
January	79.1	...	30	...	...	...	...	3	...	...	62	65	6	75	73	74	2	...	5	8
February	76.6	...	...	...	...	...	...	...	...	...	13	15	2	47	31	53	48	30	46	29
March	77.0	...	...	...	...	...	...	...	...	...	...	7	3	2	...	50	58	...	18	26
April	80.7	...	...	...	...	...	...	...	...	...	...	...	...	...	...	38	50	...	7	59

*Incomplete record.

GENERATION	JANUARY	FEBRUARY	MARCH	APRIL	MAY	JUNE	JULY	AUGUST	SEPTEMBER	OCTOBER	NOVEMBER	DECEMBER	LENGTH OF GENERATION DAYS
1		1		7									66
2				7	26								50
3						26 2							38
4							2	3					33
5								3	1				30
6									1	3			33
7										3	24		53
8	23										24		61
1		1		8									67
2				8	30								53
3						30 28							30
4						28	30						33
5							30		3				36
6									3	8			36
7										8	22		46
8	21										22		61

Summary of the Rate of Oviposition.—In Table 19 is given a complete summary of the rate of oviposition by months, from December 16, 1918, to April, 1920. The period of greatest egg production occurred during the months of May, June, and July. The maximum number of 112 eggs was deposited by female No. 21 during the month of July, 1919. On the basis of daily egg production this individual averaged more than 3.6 eggs per day during a 31-day period. Fortunately, however, the average daily rate of egg deposition is much lower. During warm weather 75 to 90 eggs were frequently deposited during a 30-day period.

Broods or Generations.—There are no distinct broods of the sweet potato weevil in the field at any season of the year. As has been shown in Table 17, the period of oviposition of the over-wintering females may extend upwards of 200 days, and since the average life cycle is completed in 35 to 40 days it is possible that the fourth generation may be started while the over-wintering females are still active in the field. This great overlapping of broods makes it impossible to determine the limits of generations under natural conditions.

To determine the maximum number of generations possible within a year under optimum conditions, observations were made on a duplicate generation series in the laboratory. Beginning February 1, 1919, two pairs of over-wintering weevils were mated, and in each case the first female emerging from the first eggs laid was mated for the succeeding generations. The results obtained are graphically illustrated in Figure 3. It will be noted that eight complete generations were produced in both cases under these conditions. These results, however, cannot be applied to field conditions without some qualification. The effect of cold weather on development and oviposition must be considered, and undoubtedly in this latitude the number of generations is less under field conditions.

During warm weather the temperatures in the laboratory approximated the normal, and it will be noted that from April 8, 1919, to October 8, 1919, five generations of weevils were obtained. Since the period of greatest activity of the sweet potato weevil occurs between these dates, it appears that at least this number of generations is possible in this locality under field conditions.

Hibernation

In this latitude the sweet potato weevil does not pass through a definite period of hibernation. With the approach of low temperatures the weevils become sluggish, and seek any available shelter that affords protection. Even after a continued period of cold weather the weevils may be found active on warm days. During January, 1918, infested tubers containing pupae and larvae in all stages of development were found in the field in Brazoria County. Active adults were also observed at that time feeding on tubers in storage. Under favorable conditions the over-wintering period may be spent in the field, but undoubtedly more weevils pass the winter successfully in stored tubers. No opportunity was available for making field observations on the mortality of the over-wintering insects.

DISSEMINATION

Since the appearance of the sweet potato weevil in the Southern States it has spread eastward and westward, especially in the Gulf region. In Texas, since 1890, the spread has been largely to the northward. Generally speaking, its dissemination has not been rapid, but nevertheless consistent with the extension of the area of sweet potato production. Dissemination may be accomplished in two ways: by artificial means, and by natural means. The former of these is by far the most important. This is well illustrated by the introduction of the pest into this and other countries, and into isolated islands, which the weevil could not have reached except by the importation of infested sweet potatoes or some closely allied plants.

Artificial Means

Undoubtedly the most important single factor affecting dissemination through artificial means is transportation, and commercial shipments of infested potato slips or draws. The production of propagation plants has been developed on a commercial scale in some sections of Texas, and where these centers of production are in weevil-infested territory, it is quite reasonable to assume that the insect is constantly being transported into new territory. The history of the insect's spread in Texas and elsewhere has developed the fact that frequently well defined isolated areas of infestation have occurred. An instance of this kind which occurred in North Texas was carefully investigated, and it was found that the material used in propagation had been received from a weevil-infested region in the southern part of the State. Similar cases have been reported by others, well illustrating the frequent occurrence and importance of this agency in dissemination.

Another very important means by which the insect is disseminated is the shipment of infested tubers. Sweet potatoes transported solely for consumption probably do not involve so great a risk in establishing new infestations, but there is always a grave possibility of the weevils' escaping en route or after reaching their destination. In tubers the weevils may frequently be carried far outside of the infested regions, even across the ocean, as has been proved by the numerous interceptions of the insect, in our ports of entry, in infested commercial shipments of sweet potatoes originating in China, Japan, Hawaiian Islands, and the West Indies.

Tubers shipped for seed purposes involve a greater possibility of dissemination, since slips produced from infested tubers invariably contain the insect in some of its stages of development.

Natural Means

The most important available natural means of dissemination is flight. There is no evidence, however, which has justified the definite conclusion that dissemination occurs very consistently through any natural means. Tryon states that the weevil, apparently, does not make long excursions on the wing, but that there are grounds for concluding that it can readily traverse an interval of ten chains or more in width. Our observations on flight at College Station are in general accordance with the above statement. Present knowledge, however, indicates that flight is not a common method of migration in the field. Since the weevil is capable of limited flight, however, it is quite conceivable that some dispersion may take place in this manner, and especially through the assistance of winds.

So long as the food supply remains ample, the insect shows little or no inclination towards migration. Even with the depletion of the food supply or harvesting of the crop, observations show that the weevils remain in the field and apparently prefer to concentrate their attack on the scattered remnants and volunteer plants, rather than risk the hazards of migration to other fields. On foot they travel slowly, especially over loose and well cultivated soil, and it is very doubtful if fields remote from centers of infestation are often reached in this manner.

NATURAL CONTROL

Parasites and Predacious Enemies

In Texas the sweet potato weevil is not effectively controlled by parasites or predacious enemies. During the course of the life history studies a mite was found to be closely associated with the adult weevil. No evidence was obtained, however, which indicated that it had any material effect on the activities and life of the adult insect. Predacious enemies are likewise of little consequence as a natural control. A number of weevils have been observed entangled in spider-webs, but owing to the infrequent occurrence of these cases, the general conclusion is that they were more or less accidental, and are of little importance as a natural control. Birds and poultry have not been observed destroying the weevils in the field.

Mortality in Diseased Tubers

Throughout the course of these studies it was frequently noted that adults were unable to emerge from tubers affected with soft rot. This was especially apparent in cases where the effect of the disease was pronounced, and the tubers had become exceedingly moist. Adults are also unable to escape from tubers that have become too dry and hard. In the laboratory these factors resulted in a considerable mortality among the immature stages of the insect.

Climatic Conditions

The climatic conditions obtaining in the Gulf region of this State appear to be especially favorable for the development of the sweet potato weevil. While the insect is able to survive the winters in the southern and north-central parts of the State, the injury is usually less severe. However, this cannot be attributed wholly to climatic conditions, since it has been definitely shown by Conradi that the weevil can withstand successfully the minimum temperatures usually experienced in this locality. The extent to which low temperatures afford a natural check on the dissemination of the weevil is still an open question, but from the history of the insect's progress in Texas it appears safe to assume that our minimum winter temperatures do not result in an effective natural control.

To determine the effect of the maximum summer temperatures on the developing stages of the weevil, infested tubers were exposed to the direct rays of the sun for periods varying from 15 minutes to 1 hour. The average temperature during these exposures was 109 degrees F. The results of these experiments showed no positive effect on the developing stages, and apparently normal weevils emerged in every case. Matured larvae and pupae when removed from the tuber and exposed directly were able to withstand temperature ranging from 98 degrees F. to 104 degrees F. for 15 minutes. Under natural conditions the maximum temperatures experienced in this locality undoubtedly do not result in any appreciable mortality among the adult weevils.

The influence of excessive rainfall on the development of the sweet potato weevil in the field is not important as a natural control. In order to obtain some idea of the weevil's ability to withstand overflows, several laboratory tests were made to determine the length of time for which the adult insect can float on the surface of the water and the immature stages within the tuber can survive submergence.

In the first test, 10 weevils were placed singly in rain-water contained in glass jars. All the specimens were completely submerged at the beginning of the experiment. They naturally rose to the surface and began to struggle, but made no definite progress. It was found that the surface tension of the water is sufficient to keep the weevils afloat. The maximum period that any weevil remained alive floating on the water was nearly 8 days. The average period for the 10 weevils was 96 hours.

In the second test 18 weevils were similarly placed in water containing bits of floating cork, which would more nearly approximate natural conditions. The floating cork proved to be of great assistance to the weevils in escaping from the water to the sides of the jars, while many of them climbed onto the cork. The time that these weevils lived was uniformly longer than those in the first test. In fact, only 3 weevils were drowned during the first 72 hours, and many were still alive and floating on the cork 7 days after the beginning of the experiment.

To determine how long the immature stages within the tuber can survive submergence, 12 sections of tubers containing the insect in all stages of development were submerged in rain-water in glass jars, for periods varying from 5 to 72 hours. They were then removed and kept under observation for several days. In every case, some apparently normal weevils emerged from the tubers. Two additional tubers were then submerged in a like manner for 96 and 144 hours, respectively. These tubers were nearly consumed by rots by the time they were removed, and no weevils emerged from them.

These results seem to indicate that the mortality resulting from excessive rainfall and overflows is negligible. These factors, therefore, cannot be considered effective as a natural control.

ARTIFICIAL CONTROL

Quarantine Regulations

The extensive spread of the sweet potato weevil has been effected by commerce; hence, regulations which will prevent the indiscriminate movements of infested sweet potatoes or propagation material will prove to be of the greatest value in preventing further spread of the pest to localities where it is not yet established. The efficacy of quarantine regulations has been clearly demonstrated by the cooperative effort of the Federal and State Entomologists in some sections of the South. Undoubtedly similar results could be obtained in Texas by legislative enactment of the proper quarantine regulations.

Cultural Methods

The well protected habits of the sweet potato weevil make it a difficult pest to control by any direct measure of combat, and no satisfactory means of eliminating the damage has yet been found. There are, however, certain cultural methods which combined will be effective in avoiding damage by the weevil.

Aside from the fact that the cultural methods recommended here are effective in mitigating the weevil damage, they are also considered to be good farming practices which should be employed by all sweet potato growers.

Clean Culture.—The first step in reducing the number of weevils at harvest time embodies immediate and thorough clean-up measures. When the sweet potato crop is being harvested, every tuber, so far as possible, should be gathered from the field, and all vines, fragments of roots, or other remnants should be promptly and completely destroyed by burning. The field should then be plowed and carefully cleaned up by collecting any remaining tubers, portions of tubers, roots, and vines. These precautions may then be effectively supplemented by turning hogs into the field to dispose of any tubers or fragments which have escaped notice. Since the weevil feeds exclusively on sweet potatoes and several closely related plants, especially morning-glory, it is obviously very important to keep the old field free from volunteer plants, and to destroy systematically all species of morning-glory vines in or near the field throughout the entire year.

Crop Rotation.—Since the sweet potato weevil has only a limited ability of flight, which present knowledge indicates is not the important means of dissemination, rotation of crops will prove especially valuable in controlling the pest. The first consideration in selecting a new field for planting is to have it removed as far as possible from the old weevil-infested field. The latter may be used for growing any staple or truck crops other than sweet potatoes. This increases the hazards for the insects in reaching the new plantings, and will materially reduce, if not eliminate, infestation.

Crop rotation is another cultural practice in accordance with good farming, and it can be utilized to a good advantage without additional expense in controlling the sweet potato weevil.

In addition to a good system of crop rotation, it is very important that the new fields be planted remote from the seed-bed, to prevent the latter from becoming a source of infestation. Immediately after the desired number of slips or draws has been obtained, all plants, vines, and tubers in the seed-beds should be destroyed.

Cultivation.—The lighter soil types which do not form cracks during the time of drouth are the most satisfactory for the production of sweet potatoes from the standpoint of weevil control. Weevils may reach the tubers through cracks in the soil, and this condition should be avoided whenever possible by selecting a well drained sandy or sandy loam soil for the production of this crop. Frequent and shallow cultivation should be practiced until the vines have covered the ground. This reduces the possibility of the weevils' reaching the roots as they are beginning to form. Whenever practicable, the field should be prepared on the level or in low ridges, as this method involves less likelihood that any tubers will become exposed to weevil attack.

Remedial Measures

Weevil-Free Slips or Draws.—It has been shown that the sweet potato weevil invariably reaches the field by means of weevil-infested slips or draws. Too much emphasis, therefore, cannot be placed upon the necessity for using only propagation material which is known to be free from weevils. The safest procedure is to obtain the slips or draws from a region where the weevil does not occur. If, however, it is necessary to produce home-grown propagation plants, extreme pains should be taken to obtain "clean tubers" for the draw-bed, and the plants should be carefully inspected before they are transplanted into the field.

The use of clean planting stock, together with clean culture and crop rotation, are the most important means of combating this pest in the field. The success that is attained in eliminating losses will depend upon the concerted and cooperative observance of these measures by all growers in the weevil-infested territory of the State.

Spraying with Arsenical Poisons.—The experiments of Conradi and High have shown that the sweet potato weevil can be destroyed by spraying with lead arsenate and zinc arsenite. No opportunity was available during our studies on the sweet potato weevil to ascertain the value of combating the pest in the field by means of arsenical poisons. Chittenden, in reporting the results obtained by High in South Texas, states that in the first experiment where actual count was possible, 80 per cent. of the weevils were killed with zinc arsenite when used at the rate of 1 pound of the powder to 40 gallons of water, with 15 pounds of cactus solution used as a spreader and sticker. The results of further tests by High with the same poison and lead arsenate indicate that spraying, if thoroughly applied at the proper time, will reduce the infestation and damage. The first application of poison should be made as soon as the first weevils have appeared. In case of severe infestation, two or three successive sprays should be applied at intervals of a week or ten days.

Spraying should not be depended upon for a complete control. Present knowledge, however, indicates that it is an effective supplementary measure to the recommendations given above, and should be practiced whenever possible in the early season when the plants are still quite small, to destroy the first appearing weevils.

Harvesting.—Prompt harvesting will result in a further reduction of the number of weevils. All very badly infested tubers are useless, and should be sorted out and immediately destroyed, together with the vines, at the time the potatoes are dug. The tubers which are not too heavily infested may be fed to stock, after thoroughly cooking them to destroy all the weevils. The crop should then be treated with carbon bisulphide, as soon as possible, in order to destroy all weevils and immature stages in the tubers which are not eliminated by the precautions suggested above.

In handling weevil-infested sweet potatoes, one should exercise extreme care to prevent all possibility of any weevils' escaping, and affording further opportunity for propagation of the pest.

Storage.—Usually the temperature obtaining in the curing or storage house is sufficient to maintain activity among the weevils. When infested sweet potatoes are placed in storage, the weevil finds itself in the presence of practically ideal conditions to continue its work throughout the winter months. Active weevils were observed frequently during January, 1918, among stored sweet potatoes in Matagorda County. The evidence of weevil injury noted at the same time was also common. Obviously it is very important to sort out carefully all infested tubers before the crop is placed in storage.

The storage house should be located as far as possible from the sweet potato fields in order to prevent it from becoming a source of infestation. It should be so constructed that the tubers can be inspected readily for the presence of the weevil, and fumigated in case of necessity.

Storing sweet potatoes in banks or pits is not advisable, since they cannot be carefully inspected at any time after being placed in storage. Effective fumigation of tubers stored in this manner is also impossible. The ready availability for inspection and fumigation are the most important requisites of proper storage for eliminating losses from weevil attack. These points should be given full consideration in designing and constructing the sweet potato storage house.*

In some sections of this State the sweet potato crop is stored in large community curing houses. These buildings are designed and constructed so that fairly constant temperatures can be maintained. After the sweet potatoes are cured by holding the temperature at 75 to 80 degrees F. for 10 to 18 days, the building is then gradually cooled and kept as nearly as possible at a constant temperature of 55 degrees F. Storage in this manner will insure the minimum loss from weevil injury, and should be utilized whenever possible. Before placing the new crop in the storage house the latter should be thoroughly renovated and fumigated. Cured or kiln-dried potatoes are not immune from attack by the weevil.

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*The reader is referred to Texas Station Bulletin No. 250, "Storage and Diseases of Sweet Potatoes in Texas", for complete information concerning the construction of a storage house for sweet potatoes.

Fumigation.—The results of experiments with carbon bisulphide as a fumigant for controlling the sweet potato weevil show that the insect can be destroyed in all its stages by using this chemical in a tight bin or container, at the rate of 4 pounds to 1,000 cubic feet of space, with a 24-hour exposure. It has been noted that under certain conditions the fumes of carbon bisulphide affect the tubers unfavorably and apparently hasten decay. This appears to be especially true when the tubers contain a high percentage of moisture. Knowledge concerning the factors responsible for this condition is incomplete at the present time. Carbon bisulphide must therefore be used with extreme caution, and its use in weevil control cannot be recommended unqualifiedly. The fumigated tubers should be disposed of as soon as possible after they have been treated.

Summary of Control Measures

1. Legislative enactment of quarantine regulations, which prevent the movement of infested sweet potatoes or propagation plants from infested localities to regions where the weevil does not exist, will prove to be the most effective measure in preventing further spread of the pest.
2. Destroy all volunteer sweet potato plants and morning-glory vines on the premises throughout the year.
3. Practice crop rotation and never grow sweet potatoes on the same land during successive years.
4. Plant the new crop as far as possible from the seed-bed and storage house.
5. Frequent shallow cultivations prevent the soil from cracking and reduce the possibility of any weevils' reaching the roots thus exposed.
6. Whenever possible use only seed sweet potatoes or propagation plants grown in a region where the weevil does not occur.
7. Destroy the first appearing weevils by spraying with arsenical poisons.
8. Harvest as soon as the crop is matured, and exercise every precaution to remove all the tubers from the field. Destroy all useless material and the vines by burning in the field immediately after harvesting. Cook the infested tubers before feeding them to stock.
9. In handling infested tubers use extreme caution to prevent any weevils from escaping.
10. Fumigate infested tubers with carbon bisulphide when they can be utilized soon after treatment.
11. Do not store tubers in banks or pits. Whenever possible utilize the advantages offered by community storage houses, or construct a suitable house in which the tubers are kept dry and are available for inspection at all times.
12. Cooperation by all grows in the observance of these measures is necessary to obtain the maximum reduction of the losses incurred from the ravages of the sweet potato weevil.

SUMMARY

The sweet potato weevil, *Cylas formicarius,* is an introduced pest. It is the most destructive insect enemy of sweet potatoes in Texas, and is widely distributed within the State. The climatic conditions of the

Gulf region are especially favorable for its development. All varieties of sweet potatoes grown in Texas are attacked by the weevil, and the annual loss resulting from the ravages of this pest is very great.

The average life cycle comprises 35 to 40 days under favorable conditions. More than 500 eggs may be deposited by the female weevil, although the average number is considerably less. The length of adult life is often protracted, and may extend upwards of 300 days. In stored tubers feeding and breeding may be continued throughout the year. Under laboratory conditions eight generations of weevils were obtained in a year. The sweet potato weevil does not enter into a definite period of hibernation at College Station.

There were no parasites or predacious enemies observed that are of economic importance. Artificial measures of control must be used in combating this pest. Crop rotation and clean culture are important features in controlling the insect. Remedial measures consist of: (1) spraying with arsenicals; (2) the use of weevil-free propagation plants; (3) prompt and thorough harvesting; (4) fumigation with carbon bisulphide; and (5) proper storage.

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California.—Calif. Dept. Agr. Mthly. Bull., v. 4, nos. 5 & 6, p. 287. Intercepted from China and Japan.

Do. *Loc. cit.*, v. 4, no. 7, p. 347. Intercepted from China.

Do. *Loc. cit.*, v. 4, no. 8, p. 401. Intercepted from China.

Do. *Loc. cit.*, v. 4, no. 10, p. 486. Intercepted from China.

Do. *Loc. cit.*, v. 4, no. 11, p. 529. Intercepted from China.

Do. *Loc. cit.*, v. 4, no. 12, p. 576. Intercepted from China.

Do. *Loc. cit.*, v. 5, no. 7, p. 271. Intercepted from Hawaii.

Do. *Loc. cit.*, v. 5, no. 11, p. 422. Intercepted from China.

Do. *Loc. cit.*, v. 5, no. 12, p. 451. Intercepted from China.

Do. *Loc. cit.*, v. 6, no. 1, p. 36. Intercepted from China.

Do. *Loc. cit.*, v. 6, no. 2, p. 66. Intercepted from China.

Do. *Loc. cit.*, v. 6, nos. 3 & 4, p. 119. Intercepted from China.

Do. *Loc. cit.*, v. 6, no. 6, p. 261. Intercepted from China.

Do. *Loc. cit.*, v. 6, nos. 11 & 12, pp. 483-4. Intercepted from China.

Do. *Loc. cit.*, v. 7, no. 9, p. 522. Listed among destructive pests kept out of state.

Do. *Loc. cit.*, v. 8, no. 1, p. 31. Intercepted from Texas.

Do. *Loc. cit.*, v. 8, no. 2, p. 84. Intercepted from China.

Do. *Loc. cit.*, v. 8, no. 3, p. 126. Intercepted from China.

Do. *Loc. cit.*, v. 8, no. 5, p. 271. Intercepted from China.

Do. *Loc. cit.*, v. 8, no. 7, p. 431. Intercepted from China.
Do. *Loc. cit.*, v. 8, no. 9, p. 544. Intercepted from Hawaii.
Do. *Loc. cit.*, v. 8, no. 12, p. 722. Intercepted from Texas.
Do. *Loc. cit.*, v. 9, no. 9, p. 388. Intercepted from China.
Do. *Loc. cit.*, v. 11, no. 1, p. 71. Intercepted from Hawaii.
Do. *Loc. cit.*, v. 11, no. 4, pp. 415, 419. Intercepted from Louisiana and Texas.
Florida.—Fla. St. Pl. Bd. Quar. Bull., v. 1, no. 4, p. 173. Intercepted from Cuba.
Do. *Loc. cit.*, v. 2, no. 1, p. 102. Intercepted from Cuba.
Do. *Loc. cit.*, v. 2, no. 3, p. 151. Intercepted from Cuba.
Do. *Loc. cit.*, v. 2, no. 4, p. 194. Intercepted from Cuba.
Do. *Loc. cit.*, v. 3, no. 2, p. 111. Intercepted from Cuba and Texas.
Hawaii.—Terr. Hawaii Bd. Agr. & Forst. Rept. Div. Ent., p. 108. 1908. Intercepted from China.
Mississippi.—Miss. St. Pl. Bd. Quar. Bull., v. 1, no. 2, p. 13. Intercepted from Cuba.
Do. *Loc. cit.*, v. 1, no. 4, pp. 17-21. Intercepted from Louisiana and Cuba.
United States.—Jour. Ec. Ent., v. 14, no. 4, p. 354. Intercepted from Nassau, Cuba, Mexico, Jamaica, Isle of Pines, and Porto Rico.
Do. *Loc. cit.*, v. 15, no. 2, p. 160. Intercepted from Cuba and Mexico.